XIX. *On the Amount and Changes of the Polar Magnetism at certain positions in Her Majesty's Iron-built and Armour-plated Ship 'Northumberland.' By* Frederick John Evans, *Staff Captain, R.N., F.R.S., Chief Naval Assistant, Hydrographic Department, Admiralty.*

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In the year 1860 an official report made by me on the Deviations of the Compass observed in all the Iron-built Ships, and in a selection of Wood-built Ships in Her Majesty's Navy, and in the Iron Steam-ship 'Great Eastern,' was communicated by Captain Washington, R.N., F.R.S., the Hydrographer of the Admiralty, to the Royal Society, and was published in the Philosophical Transactions for 1860, p. 337.

In the year 1865, with the sanction of the Lords Commissioners of the Admiralty, and in conjunction with Archibald Smith, Esq., F.R S., I presented to the Society a paper on the Magnetic Character of the Armour-plated Ships of the Royal Navy, which was published in the Philosophical Transactions for 1865, p. 263.

These papers contained a reduction and discussion of observations of the deviations of the compass, and of the horizontal and vertical magnetic force made on board a large number of iron-built ships at different positions in the ship, at different times, and in different geographical positions; and comprised almost all the results of any value or importance regarding the deviations of the compass which up to the time of that publication had been obtained in the classes of ships to which they related.

The system pursued in the Compass Department of the Royal Navy of making careful observations whenever the occasion offers, of the deviations and horizontal and vertical force in the ships of the Royal Navy, and of reducing such observations so as to obtain the magnetic coefficients $\mathfrak{A}$, $\mathfrak{B}$, $\mathfrak{C}$, $\mathfrak{D}$, $\mathfrak{E}$, λ, μ, will, I hope, enable me hereafter to lay before the Society a continuation of the former papers, in which I trust one of the deficiencies, viz. the want of a variety of observations made in the same ship in different geographical positions, will be removed by the zeal of the Navigating Officers now serving in several of Her Majesty's ships on foreign stations.

In the meantime I take the opportunity of an unusually detailed set of observations having been made in the latest and largest of the armour-plated ships, the 'Northumberland*,' to lay before the Society, with the sanction of the Lords Commissioners of the

* The observations discussed in this paper were made, and the coefficients computed, by Staff Commander William Mayes, my successor as Superintendent of Compasses of Her Majesty's Navy; and I am happy to have an opportunity of bearing testimony to the care and zeal with which he has discharged the duties of his office. I

Admiralty, some results as to the amount and changes of the magnetic forces at several positions in that ship.

These results may be thought to have some special interest from the circumstance that the 'Northumberland' was made the subject of an attempt to "depolarize" her, which created some interest and expectation not only in the general public, but even in the Naval profession*.

The 'Northumberland' is an iron-built ship of 6621 tons, 400 feet long, $59\frac{1}{4}$ broad, $26\frac{1}{4}$ feet draught of water, 1350 horse-power, screw engines, armour-plated completely round, with plates of an average of 6 inches in thickness. She has further three complete iron decks supported by iron beams and iron uprights, and a poop-deck of wood, but supported by iron beams and iron uprights. The five lower masts are also of iron. The weight of iron employed in the construction of the hull was about 4250 tons, and in the armour-plating about 1550 tons.

The ship was built at Millwall on the river Thames; the direction of her head in building being N. $39\frac{1}{2}°$ E. magnetic. Contrary to the usual practice with ships built on a slip, the armour-plating was completed previous to launching; the latter operation it may be recollected was performed with great difficulty and occupied several days. The launch was completed on the 17th April, 1866, when the ship was anchored in the river, and allowed to swing with the tide. On the 18th April she was towed to the Victoria Docks, where, on the recommendation of the Compass department, she was placed in a direction as nearly opposite to that of building as could be conveniently arranged (viz. S. 22° W. magnetic).

Unfortunately two large iron-plated ships (one iron-built) lay close alongside, and no doubt affected considerably the magnetic phenomena observed in the 'Northumberland.' This circumstance prevents the observations made during her stay in the Victoria Docks being strictly comparable with those made before and afterwards; and this must be borne in mind in looking at the Tables. It has, as far as possible, been allowed for in the assumed value of λ. Some irregularities were also caused by the introduction and movement of the large masses of iron constituting the steam-boilers and engines.

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have also to acknowledge my obligations to Mr. Archibald Smith, F.R.S., for the assistance which he has given me in the discussion of the observations, especially in their mathematical and graphical treatment.

* I would refer especially to two papers read before the Royal United Service Institution, London, and the discussions thereon, as published in the Journal of the Institution,—the first paper on "Terrestrial Magnetism with reference to the Compasses of Iron Ships; their Deviation and Remedies," read January 29th, 1866; the second paper on "The Demagnetization of Iron Ships, and of the Iron beams, &c. of Wooden vessels, to prevent the deviation of the Compasses, experimentally shown by means of a model," read May 6th, 1867, both papers by Evan Hopkins, C.E., F.G.S. The latter paper was also read at the Salle des Conferences, Champ de Mars, Paris (in connexion with the International Exhibition), on the 22nd June 1867, by Captain F. A. B. Craufurd, R.N.

At the end of December 1866, the ship was completed in her equipment for temporary service and steamed to Sheerness, where she remained swinging to the wind and tide till the early part of March 1867; when she steamed to Devonport, at which place, with the exception of two days' trial at sea to test the machinery in the middle of May, she has remained in a dry dock with her head directed S. 84° E. magnetic till the present time.

The positions of the compasses at which observations were made were the following:—

Standard Compass.—The 'Northumberland' having been built with her head nearly N.E., the magnetism principally developed was in the upper part of the stern and starboard quarter, and it was therefore desirable that this compass should be as far forward as possible. It was accordingly placed 172 feet from the stern, and $8\frac{3}{4}$ feet above the iron deck.

Steering Compasses.—The upper deck steering-wheel is 52 feet from the stern, under the fore part of the poop wooden deck; two compasses were placed close in front of it 6 feet apart, each 4 feet above the iron deck, and 3 feet 8 inches below the iron beams supporting the poop-deck.

Poop Compass.—This compass was placed on the fore extreme of the poop-deck, and 9 inches before the line joining the steering compasses, and 4 feet above the poop-deck. In the selection of a place for these latter compasses there was no room for choice; the arrangements of the architect and the requirements of the seaman could be alone consulted.

The results of the observations will be found in the Table appended to this paper, and will include a few made at temporary positions not necessary to describe in detail.

For a complete explanation of the meaning of the quantities tabulated, and the method of obtaining them by observation, I must refer to the last of the two papers mentioned above. Here it may suffice to say, that if

ζ represents the magnetic azimuth of the ship's head,

ζ' the azimuth by disturbed compass, $\delta = \zeta - \zeta'$ the deviation, then

$$\sin\delta = \mathfrak{A}\cos\delta + \mathfrak{B}\sin\zeta' + \mathfrak{C}\cos\zeta' + \mathfrak{D}\sin(2\zeta' + \delta) + \mathfrak{E}\cos(2\zeta' + \delta) \text{ exactly,}$$

or

$$\delta = A + B\sin\zeta' + C\cos\zeta' + D\sin 2\zeta' + E\cos 2\zeta' \text{ approximately.}$$

Of these coefficients $\mathfrak{A}$, $\mathfrak{D}$, $\mathfrak{E}$ (or A, D, E) depend solely on the transient magnetism induced in the soft iron, and therefore cannot be affected by any artificial magnetization, or demagnetization.

$\mathfrak{B}$ (or B) depends partly on the magnetism induced in soft iron by the earth's vertical force, partly on the permanent or subpermanent magnetism of the hard iron. $\mathfrak{C}$ (or C) depends on the last. It is therefore to the changes in $\mathfrak{B}$ and $\mathfrak{C}$ only that we are to look for the effects of polarization or depolarization.

λ is a factor almost always less than unity, representing the mean force, to north, as affected by the soft iron in the ship.

$\lambda\mathfrak{B}$ is the mean force, or, in other words, the polar force of the ship, to head.

$\lambda\mathfrak{C}$ is the mean or polar force to starboard, $\lambda\sqrt{\mathfrak{B}^2+\mathfrak{C}^2}$ the mean or polar horizontal force of the ship; each in terms of the earth's horizontal force as unit.

$\frac{\mathfrak{C}}{\mathfrak{B}}$ is the tangent of the angle which the direction of the ship's polar horizontal force makes with the line drawn to the ship's head, or the "starboard angle."

μ is the mean or polar force downwards of earth and ship, in terms of the earth's vertical force as unit; and depends partly on the subpermanent force of the hard iron, partly on vertical induction.

$\left(\mathfrak{D}+\frac{\mu}{\lambda}-1\right)\tan\theta\times1^\circ$ is the heeling coefficient to windward, and represents the deviation to windward caused by an inclination of the ship of 1°, when her head is North or South by compass.

The values of these coefficients, and also of a and e, the coefficients of horizontal induction, headward and to starboard, for the several compasses are given in the General Table appended to this paper.

The character of the deviations of the standard, steering and poop compasses and of their changes, may be thus generally described.

In each, the $\mathfrak{B}$ has originally a large negative value, caused by the ship having been built nearly head North, (N. 39°½ E.). This gradually diminishes as she lies in the Victoria Docks with her head to the South, but, as is usually found, shows a tendency to return to its original value when the ship is allowed to swing. $\mathfrak{C}$, which has originally a large positive value caused by the starboard side having been to the South, decreases, and even changes its sign in Victoria Docks, but returns to its original sign and nearly to its original value when the ship swings at Sheerness.

In the poop and steering compasses down to 1st January 1867, and in the Standard compass throughout,—except for a short period while a magnet was applied to reduce the deviation—there are no changes except what may be considered to be due to the ship's position, and to the other circumstances adverted to; but as regards the poop and steering compasses between 1st and 26th January, the case is different; the causes of the difference, and the inferences to be drawn from it, it is proposed now to consider.

Early in 1866, Mr. Evan Hopkins*, C.E. applied for a patent for "An improved method of correcting the Deviation of Compasses in Iron Ships." In the provisional specification, dated 23rd January 1866, the method is described as "destroying the

* Mr. Evan Hopkins was the author of a work entitled "On the Connexion of Geology with Terrestrial Magnetism," 1844, 2nd edition, in which many singular opinions are propounded on Astronomy, Magnetism, and general Physics. I regret to have to speak of Mr. Hopkins in the past tense. He died in the middle of 1867.

polarity acquired while the ship is building, by passing electro-currents through the hull." In the final specification, dated 23rd July 1866, it is described as "moving an electro-magnet from end to end over, and in contact with the main plates of the ship." There is some obscurity in both specifications, from the patentee not distinguishing between electric currents and lines of magnetic force; but whatever may be the meaning of the method described in the provisional specification, it is certain that that method would be utterly inadequate to produce any sensible effect in a large ship.

The method described in the final specification would no doubt produce, wherever applied, some local effect; but the effect produced by the local application of magnetic force of high and rapidly varying intensity must necessarily be wholly different from that which has arisen from the general application of a force of low and uniform intensity, and the former cannot possibly produce any general destruction of the latter. The process is in fact not one of general demagnetization, but of partial counter magnetization. The result will be an irregular distribution of magnetism of very variable intensity, necessarily very unstable, and producing, wherever effective, a rapidly varying field of force. The justice of these remarks will, I think, be shown in the sequel.

In April 1866 Mr. Hopkins applied to the Admiralty for permission to experiment on the 'Northumberland,' the largest and most heavily armoured ship in the Royal Navy. The application was in the usual course referred to the Magnetic department, and on a report that no injury was to be apprehended, the required permission was granted*.

The first trials were made on the 4th August 1866, and are thus described by Mr. Hopkins in a report dated 10th August, and received at the Admiralty a few days afterwards. "After having ascertained the actual magnetic condition of the ship, I applied two of Grove's batteries of five cells each, with the electro-magnets to the main plates at the stern and bow, and in a few hours the polarity of the hull was destroyed"†.

The results of the observations shown in the General Table, I think entitle me to say that there is no foundation whatever for the statement that the polarity of the hull was destroyed; there is in fact no evidence of its having been affected in even the slightest degree. To facilitate the examination I subjoin the values of the semicircular deviation of the two compasses which were most continuously examined in the period comprising the 4th August, viz. the poop and starboard steering compasses; the position of the Standard compass being at that time occupied by machinery.

* That report, for which I am responsible, was made on the supposition that the process was one to be applied to the hull of the ship generally, according to the specification of the patent. Had I understood that the iron in the immediate vicinity of any compass was to be magnetized to a high degree of intensity, I should certainly have reported differently; and it will be seen in the sequel that from the results of Mr. Hopkins's experiments, I was obliged to submit that no such experiments for the future be permitted within 20 feet of any compass placed for the navigation of the ship.

† This statement was subsequently repeated at a Meeting of the British Association for the Advancement of Science held at Nottingham in 1866, in a paper "On the Depolarization of Iron Ships, to prevent the Deviation of the Compass," by Mr. Evan Hopkins, C.E. See Athenæum of September 8th, 1866.

1866.	Maximum of Semicircular Deviation. Poop compass.	Starboard Steering compass.
	°	°
May 29th . . .	$48\frac{3}{4}$	$39\frac{1}{2}$
July 12th . . .	$64\frac{1}{2}$	50
August 10th . . .	$55\frac{3}{4}$	$46\frac{1}{2}$

In each case it will be seen there is a slight decrease in the interval comprising the 4th August, but the decrease does not exceed half the increase in the preceeding interval; and seems only the recovery from an anomalous increase in July, probably attributable to some external disturbing cause of the nature before mentioned, viz. the proximity of the two armour-plated ships in the Victoria Docks.

The next and final trial was made between the 1st and 26th January 1867, at Sheerness: ten or twelve days were occupied in passing large electro-magnets along the outside of the ship from the water-line to the top sides. Subsequently, and apparently as an after thought,—as no mention is made in either specification of internal demagnetization on so large a scale,—about five days more were occupied in applying the electro-magnets to the transverse iron beams of the poop and upper deck nearest the poop and steering compasses, and to two adjacent vertical iron stanchions supporting the upper deck. As no appreciable effect was produced on the Standard compass, or on any compasses except those in the immediate vicinity of the beams and stanchions operated on, we may have confidence in attributing the change which took place entirely to the latter operations.

The following Tables, derived from the General Table, furnish the means of deciding this question.

TABLE I.

At position of the undermentioned compasses.	(I.) B Part of semicircular deviation from Headward force.	(II.) C Part of semicircular deviation from Transverse force.	(III.) $\sin^{-1}\sqrt{\mathfrak{B}^2+\mathfrak{C}^2}$ Maximum of semicircular deviation.	(IV.) $\tan^{-1}\frac{\mathfrak{C}}{\mathfrak{B}}$ Starboard angle.	(V.) μ Mean vertical force of earth and ship, in terms of earth's horizontal force as unit.	(VI.) Heeling error to windward for 1° of heel.	(VII.)
	°	°	°	°		° ′	
1st January 1867. Standard	−37	+ $4\frac{1}{2}$	$40\frac{1}{2}$	$173\frac{3}{4}$	1·223	+1 18	
Starboard steering	$-39\frac{3}{4}$	$+15\frac{1}{4}$	$46\frac{1}{2}$	$161\frac{1}{4}$	1·056	+1 4	
Poop	$-48\frac{3}{4}$	$+15\frac{1}{4}$	$56\frac{1}{2}$	$164\frac{1}{4}$	1·469	+2 1	
Port steering	−43	$+19\frac{3}{4}$	51	$157\frac{1}{4}$			

TABLE II.

26th January 1867. Standard	$-36\frac{1}{4}$	+ 7	$40\frac{1}{4}$	$170\frac{1}{4}$	1·271	+1 27	
Starboard steering	− $2\frac{1}{2}$	$+38\frac{1}{4}$	$36\frac{3}{4}$	$94\frac{1}{2}$	1·250	+1 45	
Poop	− $3\frac{1}{4}$	$+12\frac{1}{4}$	$12\frac{1}{4}$	$104\frac{3}{4}$	·986	+0 37	
Port steering	− $4\frac{1}{4}$	−11	11	246			

TABLE III.—Amount and direction of Magnetic Forces on 1st January 1867.

	$\lambda\,\mathfrak{B}$ Ship's force to head.	$\lambda\,\mathfrak{C}$ Ship's force to starboard.	$(\mu-1)\tan\theta$ Ship's force downwards.	$\lambda\sqrt{\mathfrak{B}^2+\mathfrak{C}^2}$ Horizontal force of ship.	$\sqrt{\text{Col. III}^2+\text{IV}^2}$. Total force of ship.	$\tan^{-1}\frac{\mathfrak{C}}{\mathfrak{B}}$ Starboard angle of ship's force.	$\tan^{-1}\frac{\text{Col. III.}}{\text{Col. IV.}}$ Dip of ship's force.
						°	° ′
Standard	−·562	+·062	+ ·553	·566	·791	$173\frac{3}{4}$	+44 24
Starboard steering	−·546	+·186	+ ·139	·578	·595	$161\frac{3}{4}$	+13 32
Poop	−·691	+·196	+1·163	·720	1·368	$164\frac{1}{4}$	+52 46
Port steering.	−·580	+·242	.....	·628	.....	$157\frac{1}{2}$	

TABLE IV.—Amount and direction of Magnetic Forces on 26th January 1867.

Standard	−·554	+·094	+·672	·562	·876	$170\frac{1}{4}$	+50 5
Starboard steering	−·037	+·477	+·620	·478	·783	$94\frac{1}{2}$	+52 25
Poop	−·051	+·175	+·035	·181	·184	$104\frac{3}{4}$	−10 57
Port steering	−·062	−·141	.....	·153	.....	246	

TABLE V.—Amount and direction of additional forces introduced between January 1st and 26th, 1867.

Standard	+·008	+·032	+ ·119				
Starboard steering	+·509	+·291	+ ·481	·586	·758	+30	+38 25
Poop	+·648	−·021	−1·198	·648	1·362	− 2	−61 35
Port steering	+·518	−·383	.....	·644	.....	$-36\frac{1}{2}$	

The values of B and C in Table I. show the remarkable amount of accordance in the deviations of the *four* compasses; a similarity which clearly indicates that the cause of the deviations is to be sought for, not in the iron in the immediate vicinity of those compasses, but in iron at such a distance that the distance between the compasses does not materially affect its action on them.

The values of B and C in Table II. show an important change in *three* of the compasses. The value of B for the starboard steering, poop, and port steering are nearly reduced to zero, showing the introduction of a powerful force attracting to the bow of the ship, or repelling from the stern. With C the case is very different: in the port compass a deviation to port is produced, in the starboard compassa deviation to starboard; indicating the introduction of a repelling force between the two. The same conclusion may be drawn, and perhaps with greater facility, from a comparison of the value of the quantities in columns III. and IV.

The quantities in columns V. and VI. show that the change produced is an upward force on the poop compass, and downward on the starboard steering compass; pointing to a repelling force emanating from a point or region at a height intermediate between the height of the two compasses. These several comparisons show that the change was really caused by a repelling force (a north pole) being introduced in the iron of the poop-deck a little abaft the poop compass.

The precise amount and direction of the force so introduced, and the changes it caused in the previously existing forces, will be seen distinctly by the mathematician from Tables III., IV., V.

The action of the several forces may perhaps be more clearly apprehended when they are represented graphically as in Plate XXXI. In this, fig. 1 represents the projection of lines indicating the amount and direction of the magnetic forces which act on the three compasses on the horizontal plane. Fig. 2 represents the projection of the same lines on the fore and aft vertical plane. The figures are drawn to a scale in which one-fourth of an inch represents one foot, and also one-tenth of the earth's horizontal force. The lightly dotted parts represent iron.

P, Q, R represent the positions of the port, the poop, and the starboard steering compasses respectively; Pp, Qq, Rr represent the projection of lines representing the magnetic forces of the ship at these positions on the 1st January 1867; Pp', Qq', Rr' the same projection on the 26th January 1867; Pp'', Qq'', Rr'' the projection of the additional forces introduced in the interval.

In fig. 1 the near approach to parallelism and equality in Pp, Qq, Rr indicate a distinct cause of magnetic force. The lines Pp'', Qq'', Rr'' produced backwards nearly meet in a point about 5 feet abaft the poop compass; indicating that the additional force is introduced at or near that point. A similar convergence of the line Qq'', Rr'' in fig. 2 indicates that the point lies in or near the poop deck, and suggests that it arose from the magnetization of the central part of the iron beams of the poop deck, modified possibly by some magnetization of the beams of, or stanchions supporting the upper deck.

On the 28th February, and preparatory to the ship being navigated to Devonport, the deviations and magnetic forces were observed. The deviation of the Standard compass being too great for the safe navigation of the ship, and the deviation of the starboard steering compass being so great as to make it practically useless, it was necessary to reduce their semicircular deviations by the application of fixed magnets. The process employed, and which is that generally employed in the Royal Navy, is identical with one of the two methods described by the Astronomer Royal in his well-known paper on the magnetism of iron-built ships (Philosophical Transactions, 1839, see page 196), and may be described as follows.

The coefficients $\mathfrak{B}$, $\mathfrak{C}$, λ being found by observation, or where necessary $\mathfrak{B}$ and $\mathfrak{C}$ being found by observation, and λ being estimated; we have $\lambda\sqrt{\mathfrak{B}^2+\mathfrak{C}^2}$ the tangent of the semicircular deviation when the polar force acts to the east or west of the compass, and $\frac{\mathfrak{C}}{\mathfrak{B}}$ the tangent of the "starboard angle." If we desire to correct the semicircular deviation completely, a magnet of suitable size, adequate power, and proved permanence is selected from those in store at the Compass Observatory at Woolwich. The distance above or below the card at which this magnet, when placed East and West, will produce a deviation of which the tangent is $\lambda\sqrt{\mathfrak{B}^2+\mathfrak{C}^2}$, is ascertained by actual trial. The magnet is then inserted into the pedestal of the Standard compass at the ascertained distance immediately below the centre of the card and in the direction of the starboard angle, the poles being so placed as to counteract the polar magnetism of the ship.

As in newly built ships the polar force is generally undergoing a process of gradual diminution, it is generally considered best not to correct entirely the semicircular devia-

tion, but to under correct it, leaving about 5° uncorrected. This was the object sought in the application of magnets to the 'Northumberland'; and the success with which it was effected, and the certainty of the process, may be seen by the following comparison of the deviations on the 28th February and the 2nd March.

		A	B	C	D	E
Standard compass	February 28, 1867	+0° 01′	−36° 13′	+ 7° 09′	+7° 19′	+0° 59′
	March 2	−0 14	− 4 55	+ 0 14	+7 13	+1 15
Starboard steering-compass	February 28	+0 41	− 5 20	+40 41	+6 28	+2 40
	March 2	−0 18	− 4 15	− 1 04	+6 42	+1 44

In general no attempt is made to correct the quadrantal deviation, that deviation and the residual semicircular deviation being the subject of tabular correction. I may observe that in some cases Mr. AIRY'S second or tentative mode of correcting, viz. by one or more fore and aft and transverse magnets, is adopted, but only when special circumstances prevent the first method being applicable. In general by the process first described, all that is necessary or desirable in the way of mechanical correction can be effected.

In the middle of March 1867, the 'Northumberland,' as before stated, was placed in a dry dock at Devonport, and the magnets were removed; her head in dock was S. 84° E. magnetic. Such a position would, from all former experience, and especially in a newly launched ship, be expected to increase considerably the force to starboard, or the value of +$\mathfrak{C}$, but without much alteration in the fore and aft force, or the value of $\mathfrak{B}$, in those compasses in which the $\mathfrak{B}$ and $\mathfrak{C}$ were caused by the general magnetism of the hull. We have continuous observations to the end of 1867 strictly comparable as regards the Standard compass; but as regards the other three compasses allowance must be made for the introduction between August and December 1867 of five iron beams* to extend the light poop deck before the poop compass.

The changes in the Standard compass while the ship lay in dock with her head S. 84° E. are shown in the following Table.

	[1867].	$\mathfrak{B}$.	$\mathfrak{C}$.
Swinging at anchors	January 26th	−·637	+·108
	February 28th	−·637	+·110
Head S. 84° E. magnetic from middle of March	June 26th	−·576	+·277
	August 29th	−·569	+·256
	December 10th	−·593	+·329

* The effect of the introduction of the five new poop-deck beams when the ship's head was S. 84° E. magnetic would be to increase $\mathfrak{C}$ and $\mathfrak{D}$ and diminish λ. The exact value of the altered $\mathfrak{C}$ cannot be computed without knowing the altered values of $\mathfrak{D}$ and λ; and these cannot be ascertained till the ship is again swung. I think, however, it is certain that the change in $\mathfrak{D}$ cannot exceed ·017 (or 1° in $\mathfrak{D}$), and the change in λ cannot exceed ·020, and I have accordingly inserted in the General Table, under date 10th December 1867, the values of $\mathfrak{B}$ and $\mathfrak{C}$ computed as well with the original values of $\mathfrak{D}$ and λ, as with values allowing these amounts. It may be safely assumed that the true values lie between the two as limits.

These results are clearly attributable to the change in the general magnetism of the ship due to position; the fore and aft force has been little affected, but there is a decided increase in the transverse force, $= +\cdot219$.

With respect to the compasses affected by Mr. HOPKINS's process, the results are widely different:—in seven months (end of January to end of August), as will be seen by the following Table, at the starboard steering $-\mathfrak{B}$ has increased ·183, $\mathfrak{C}$ having scarcely changed in value; at the poop compass $-\mathfrak{B}$ has increased ·281, and $+\mathfrak{C}$ ·162; at the port steering compass $-\mathfrak{B}$ has increased ·098, while the $\mathfrak{C}$ has increased ·320; so that the increase of the $\mathfrak{C}$ in the poop compass is almost exactly the mean of the increase in the port and starboard compasses.

1867.	Port steering compass.		Poop compass.		Starboard steering compass.	
	$\mathfrak{B}$	$\mathfrak{C}$	$\mathfrak{B}$	$\mathfrak{C}$	$\mathfrak{B}$	$\mathfrak{C}$
January 26	−·078	−·176	−·059	+·203	−·046	+·596
February 28	−·071	−·128	−·070	+·230	−·078	+·625
June 26			−·153	+·360		
August 29	−·176	+·150	−·340	+·365	−·229	+·637
December 10.....	−·212 −·218	+·508 +·481	−·215 −·221	+·541 +·516	−·136 −·141	+·641 +·617

If we confine ourselves to the practical question of the amount of the semicircular deviation, and also of the direction of the ship's force [starboard angle], or, in other words, the direction of the neutral or zero-points of the semicircular deviation, the comparison is as follows:—

1867.	Standard.		Port steering.		Poop.		Starboard steering.	
	Maximum semi-circular deviation.	Starboard angle.	Maximum semi-circular deviation.	Starboard angle.	Maximum semi-circular deviation.	Starboard angle.	Maximum semi-circular deviation.	Starboard angle.
	°	°	°	°	°	°	°	°
January 1...	37¼	173¾	47⅓	157	51	164¼	42¾	161¼
„ 26...	37	170¼	12	246	12¾	104¾	38½	94⅓
February 28...	37	170	8¾	241	14⅓	107	41¾	97
June 26...	39⅓	155	...	...	23	112		
August 29...	38⅓	156	13¼	139½	30	133	42¾	110
December 10...	42⅓	151	33⅓	112½	35½	111⅓	40	102

From this comparison it will be seen how short lived is the apparent benefit derived from the process we have been considering.

The nature of the changes in the polar force will perhaps be more clearly apprehended if we represent them graphically, as in Plate XXXII., by taking the position of each compass as origin and laying down the points, of which $\lambda\mathfrak{B}$ and $\lambda\mathfrak{C}$ are the coordinates, as derived from the observations on January 1st and 26th, February 28th, August 29th, and December 10th, 1867.

As regards each compass, a line drawn from the origin to one of these points represents in amount and direction the polar force acting on that compass at that epoch; and a line drawn from one point to the next succeeding in order of date represents, in amount and direction, the additional polar forces acting on that compass introduced in

the interval. To avoid confusion in the figure, the lines from the origin are only drawn for the earliest date. The *joints* added to these lines, therefore, represent the additional forces introduced in each interval.

This Plate shows strikingly the contrast between the comparatively small and regular changes in the polar magnetism of the Standard compass, and the large and irregular changes in the polar magnetism of the other compasses; but at the same time shows strikingly the general analogy in the changes in these three compasses.

An attentive study of it will also show, that while the changes in the polar magnetism of the Standard compass are almost entirely from an increasing attraction to the south side of the ship, in the other compasses this is combined with an increasing attraction to, or rather a diminishing repulsion from, the point abaft the poop compass to which a powerful north pole had been communicated.

In the interval between the 28th August and the 10th December, a general headward force on the three stern compasses is also added. What was the cause of this force I am unable say; it may possibly be connected with the introduction of the five iron beams in front of these compasses, and the general hammering to which that part of the ship was consequently exposed.

The views which I have taken of the effect of the application of the electro-magnets are, I think, strongly confirmed by observations made on the 10th December 1867, at four points surrounding the position of the supposed north pole produced by them.

Of these, the position of the poop compass was one; the second was 18 feet abaft the poop compass; the third, 7 feet 3 inches abaft the poop compass, and 4 feet to port of the midship line; the fourth, 7 feet 3 inches abaft the poop compass, and 4 feet to starboard of the midship line. The values of $\mathfrak{B}$ and $\mathfrak{C}$ for these compasses were—

	$\mathfrak{B}$.	$\mathfrak{C}$.
No. 1. Poop compass	−·215	+·541
2. 18 feet abaft Poop compass	−·641	+·482
3. $7\frac{1}{4}$ feet abaft Poop compass, 4 feet to port . . .	−·457	+·260
4. $7\frac{1}{4}$ feet abaft Poop compass, 4 feet to starboard .	−·458	+·692

An inspection of these values will show that they indicate a generally attractive force to the stern and starboard sides; but modified by a repulsive force emanating from a point nearly centrically situated with respect to the four compasses. We may, in fact, I think, infer that the mean of these values, or a $\mathfrak{B}$ of −·443, and a $\mathfrak{C}$ of +·494, is due to the general magnetism of the ship, and as regards $\mathfrak{C}$ partly to the new iron beams, and that the difference from these values as to each compass arises from local magnetization. These differences—which are also multiplied by λ(·860) to express them in terms of the earth's magnetic force as unit—will be

	$\mathfrak{B}$.	$\mathfrak{C}$.	$\lambda\mathfrak{B}$.	$\lambda\mathfrak{C}$.
No. 1. Station (Poop) . .	+·228	+·047	+·196	+·040
2. „ . .	−·198	−·012	−·170	−·010
3. „ . .	−·014	−·234	−·012	−·201
4. „ . .	−·015	+·198	−·013	+·170

The interpretation of which Table is that, besides the general magnetism of the ship, there is a horizontal force nearly equal to one-fifth of the earth's horizontal force, repelling the north end of each needle from a point situated nearly in the centre of the compasses. This I conceive to be the remains of the strong north pole to which I have referred, which it will be remembered affected the poop compass with a repelling force $=\cdot 648$, and now reduced to $\cdot 200$; so that more than two-thirds of the force introduced in the operations of January 1867 seem to have disappeared in the course of eleven months; and the general result of these operations may be described as the introduction at a point in the poop-deck, a few feet abaft the poop compass, of a north pole acting on the compass with a force of nearly two-thirds of the earth's horizontal force, and which force in the course of eleven months diminished to about one-fifth of the earth's force, or to less than one-third of its original amount.

The effect of the forces introduced by the operations of January 1867, and of the gradual decay of these forces in the interval between January and December, is no less obvious in the heeling-errors of the different compasses. This error, it may be remembered, is expressed by the deviation to windward produced by an inclination of the ship of 1°, when its head is North or South by the disturbed compass.

In the interval between the 1st and 26th January 1867, there is a diminution of the heeling-error of the poop compass from 2° 1′ to 0° 37′, but an increase of the heeling-error of the starboard compass from 1° 4′ to 1° 45′. The diminution is caused by the upward force on the poop compass; the increase by the downward force on the starboard steering compass introduced in the interval.

The changes so introduced in both compasses diminish as time passes. By the 10th December that of the poop compass had risen to 1° 14′, that of the starboard steering diminished to 0° 56′. During the whole of this period the heeling-error of the Standard compass is hardly altered; the slight apparent changes being not greater than can be accounted for by unavoidable errors of observation.

We are now in a position to form an opinion as to the real nature of the changes effected by the operations of January 1867, and the advantages and disadvantages of these changes.

The process was in no sense of the word one of "depolarization," either of the whole ship or of any part of it. It was, on the contrary, the "polarization" to a high degree of intensity of a particular portion of the iron in the neighbourhood of three of the compasses. The iron so magnetized was iron capable of receiving only subpermanent magnetism, and which from its forming part of the structure of the vessel was subject to strains and concussions from which detached magnets are wholly free. The magnetism so communicated was therefore necessarily unstable and transient, and from its liability to change suddenly and unexpectedly, was a source of danger to the vessel. So strongly was I impressed with the danger that in an official report to the Admiralty of 31st January 1867, after a careful reduction of the observations the results of which are already given, I expressed the hope that, should further experiments be permitted in

Her Majesty's ships for depolarizing their hulls, the so-called "depolarization" should not be allowed "within 20 feet of any compass that may be placed for the navigation of the ship."

Nor could the effect produced, even if it had been much more permanent than it proved to be, be considered an advantage. In two out of the three compasses to which it was applied the semicircular deviation was reduced within the limits which make tabular corrections possible, not within those which allow it to be dispensed with. In the third—the starboard steering compass—the effect, though considerable, was rather a change in the direction, than a reduction of the amount, of the semicircular deviation; for it exceeded 36°, and a reduction by a magnet was still necessary. In the two compasses in which the process was effective to the extent we have mentioned, the requisite reduction might have been effected with infinitely greater ease and certainty, as well as permanency, by the application of a single magnet to each compass.

In dismissing this subject it may seem that some apology is necessary for occupying the time of the Society with the details of a process which had so little to recommend it, and which has proved injurious, not beneficial; it is, however, a process to which many persons looked with hope, and from which no one apprehended danger; both were mistaken, and in both respects it is desirable that the results of the trials should be known.

The Tables and the discussion will also I hope be accepted as an interesting example of the method now constantly practised in the Royal Navy of supplementing the observations made in "swinging" a ship, by observations of deviation and horizontal and vertical force made on one azimuth.

As regards the observations generally, the conclusions to be drawn from them, or rather which, having been already drawn from numerous other observations, are supported by those made in the 'Northumberland,' seem to be—

1. That in an iron-built ship, and in that part of her within which the Standard compass is generally placed, the polar force is that from the magnetism of the whole body of the ship, and is nearly uniform.

2. That we cannot escape from the action of that force by any care in the selection of a place for the compass.

3. That though positions may be found where from the magnetism of particular masses of iron counteracting that of the ship, the deviation will be small, yet that such positions are in general to be avoided, as the change of magnetic force in such positions will probably be larger and less regular than when the compass is only acted on by the general magnetism of the whole ship:—any attempt to produce this counteraction by magnetizing artificially masses of iron in the vicinity of a compass is to be deprecated.

4. That in iron-built ships, as at present constructed, the ship's polar force is generally so great as to make it necessary to employ magnets to equalize the directive force on different azimuths of the ship's head, even at the most carefully selected position; but that the use of correcting magnets does not dispense with the necessity of ascertaining from time to time by observations, the amount of the remaining deviations.

General Table.—Her Majesty's Ship Northumberland.

Ship.	Compass.	Place.	Date.	Approximate coefficients. A	B	C	D	E	Exact coefficients. A	B	C	D	E
				° ′	° ′	° ′	° ′	° ′					
Northumberland.	Standard.	On Stocks	Mar. and Apr. 1866	*By deviation, horizontal and vertical forces on one point*						−·157	+·427	+·133a	.....
		Off Deptford	Apr. 19, 1866							−·004	+·416	+·133a	.....
(6621 tons),		Sheerness	Jan. 1, 1867	+0 50	−36 53	+ 4 35	+7 02	−0 24	+·015	−·646	+·071	+·122	−·007
26 guns, 1350 horse-power, Iron hull, iron-plated.		Sheerness	Jan. 26, 1867	+1 12	−36 13	+ 7 02	+7 22	−0 35	+·021	−·637	+·108	+·128	−·010
		Sheerness	Feb. 28, 1867	+0 01	−36 13	+ 7 09	+7 19	+0 59	+·001	−·637	+·110	+·127	+·017
		Sheerness	**March 2, 1867**	**−0 14**	**−4 55**	**+ 0 14**	**+7 13**	**+1 15**	**−·004**	**−·091**	**+·004**	**+·126**	**+·022**
Armour bulk-heads. Rifle-tower on quarter-deck.		Devonport	June 26, 1867	*By deviation, horizontal and vertical forces on one point. Ship in dock, head* S. 84° E. *magnetic*						−·576	+·277	+·123a	.....
		Devonport	Aug. 29, 1867							−·569	+·256	+·120a	.....
		Devonport	Dec. 10, 1867							−·593	+·329	+·120a	.....
Built at Millwall, River Thames; head N. 39½° E. magnetic.	Poop.	On Stocks	Mar. and Apr. 1866	*By deviation and forces on one point*						−·788	+·358	+·090a	.....
										−·801	+·361	+·104a	.....
Plated on Stocks.		Off Deptford	Apr. 19, 1866	*From swinging through a Quadrant*						−·877	+·296	+·090a	.....
										−·890	+·291	+·104a	.....
Launched April 17, 1866.		In Victoria Docks.	Apr. 21, 1866	*By deviation and forces on one point (head* S. 22° W. *magnetic). Two iron-plated ships alongside. Steam machinery, iron masts, &c., placed on board during this interval*						−·800	+·135	+·090a	.....
			May 29, 1866							−·742	+·129	,,	.....
			July 12, 1866							−·900	+·075	,,	.....
			Aug. 10, 1866							−·821	+·099	,,	.....
			Sept. 1, 1866							−·842	+·076	,,	.....
			Oct. 24, 1866							−·814	+·003	,,	.....
			Dec. 17, 1866							−·825	+·025	,,	.....
		Sheerness	Jan. 1, 1867	+1 15	−48 43	+15 13	+5 55	−0 35	+·022	−·803	+·228	+·103	−·010
		Sheerness	*Jan. 26, 1867*	+2 14	− 3 16	+12 20	+5 39	−0 48	+·039	−·059	+·203	+·098	−·014
		Sheerness	*Feb. 28, 1867*	+0 35	− 3 51	+13 59	+6 07	+0 29	+·010	−·070	+·230	+·107	+·008
		Devonport	*June 26, 1867*	*By deviation, horizontal and vertical forces on one point. Ship in dock,* S. 84° E. *magnetic*						−·153	+·360	+·100a	.....
		Devonport	*Aug. 29, 1867*							−·340	+·365	,,	.....
		Devonport	*Dec. 10, 1867*							−·215	+·541	,,	.....
		Devonport	*Dec. 10, 1867*							−·221	+·516	+·117a	.....

Note.—The coefficients marked (a) are assumed values.

General Table (continued).—Her Majesty's Ship Northumberland.

Maximum of semicircular deviation / Mean horizontal force of ship $\sqrt{\mathfrak{B}^2+\mathfrak{C}^2}$†. Amount.	Direction.	Mean force to North, λ ‡	$\frac{1}{\lambda}$	Coefficients of horizontal induction. Headward. a ‡	To starboard. e ‡	Part of $\mathfrak{D}$ from Fore and aft induction.	Transverse induction.	Mean Vertical force, μ §	Heeling coefficient to *windward*.	Heeling coefficient for Vertical induction in transverse iron.	Vertical force and induction in vertical iron.	Variable part of Vertical force. $\frac{g}{\tan\theta}$ §	g ‡
°		°				° ′	° ′		° ′	° ′	° ′		
27½	·461	110	·860a	.....	.....	.....	.....	1·241	+1 25	.....	.....	+·007a	
24½	·416	90½	·860a	.....	.....	.....	.....	1·164	+1 11				
40½	·650	173¾	·869	1·151	−·025	−·237	−0 48	+7 50	1·223	+1 18	+0 40	+0 38	+·007	+·017
40¼	·646	170¼	·870	1·149	−·019	−·241	−0 34	+7 56	1·271	+1 27	+0 41	+0 46		
40¼	·646	170												
5¼	·091	177½	·878	1·139	−·012	−·232	−0 21	+7 34	1·168	+1 07	+0 39	+0 28	+·013	+·032
39¾	·639	154½	·885a	.....	.....	.....	.....	.....	1·272	+1 24	.....	.....	+·010a	
38½	·623	156	·885a	.....	.....	.....	.....	.....	1·232	+1 17	.....	.....	,,	
42¾	·678	151	·885a	.....	.....	.....	.....	.....	1·266	+1 22	.....	.....		
59¾	.....	155½	·800	.....	.....	.....	.....	.....	1·637	+2 50	.....	.....	+·070a	
61¾	·880	155½	·840	.....	.....	.....	.....	.....	1·691	+2 48	.....	.....	·000	
67¼	.....	161½	·800	.....	.....	.....	.....	.....	1·646	+2 52	.....	.....	+·070a	
69½	·936	161¾	·840	.....	.....	.....	.....	.....	1·596	+2 30	.....	.....	·000	
54¼	·811	170½	·800a	.....	.....	.....	.....	.....	1·529	+2 30	.....	.....	+·070a	
48¾	·753	170	,,	.....	.....	.....	.....	.....	1·531	+2 06	.....	.....	,,	
64½	·902	175½	,,	.....	.....	.....	.....	.....	1·383	+2 03	.....	.....	,,	
55¾	·827	173½	,,	.....	.....	.....	.....	.....	1·411	+2 08	.....	.....	,,	
57¾	·847	174½	,,	.....	.....	.....	.....	.....	1·449	+2 15	.....	.....	,,	
54½	·814	180	,,	.....	.....	.....	.....	.....	1·442	+2 14	.....	.....	,,	
55½	·825	178	,,	.....	.....	.....	.....	.....	1·355	+1 58	.....	.....	,,	
56½	·834	164¼	·860	1·163	−·052	−·228	−1 44	+7 30	1·469	+2 01	+0 39	+1 22	−·001	−·003
12¼	·211	104¾	·854	1·171	−·062	−·230	−2 04	+7 43	·986	+0 37	+0 40	−0 03		
14	·240	107	·894	1·118	−·010	−·202	−0 21	+6 28	·929	+0 22	+0 34	−0 12	+·033	+·082
23	·391	112	·880a	.....	.....	.....	.....	.....	·996	+0 35	.....	.....	+·030a	
30	·499	133	,,	.....	.....	.....	.....	.....	1·044	+0 43	.....	.....	,,	
35½	·580	111½	,,	.....	.....	.....	.....	.....	1·230	+1 14	.....	.....	,,	
34	·561	113	·860a											

$$a = \lambda\mathfrak{D} - (1-\lambda).$$
$$e = -\lambda\mathfrak{D} - (1-\lambda).$$

Part of $\mathfrak{D}$ from
- Fore and aft induction $= \frac{a}{2\lambda} = \frac{\mathfrak{D}}{2} - \left(\frac{1}{\lambda} - 1\right)$.
- Transverse induction $= -\frac{e}{2\lambda} = \frac{\mathfrak{D}}{2} + \left(\frac{1}{\lambda} - 1\right)$.

Heeling coefficient to *windward* $= \left(\mathfrak{D} + \frac{\mu}{\lambda} - 1\right)\tan\theta$.

Part of heeling coefficient.
- from Vertical induction in transverse iron ..... $= \left(\mathfrak{D} + \frac{1}{\lambda} - 1\right)\tan\theta$.
- from Vertical force and Vertical induction in Vertical iron..... $= \left(\frac{\mu}{\lambda} - \frac{1}{\lambda}\right)\tan\theta$.

† Mean force to North (λH) being unit. ‡ Earth's Horizontal force (H) being unit. § Earth's Vertical force (Z) being unit.

GENERAL TABLE (continued).—Her Majesty's Ship Northumberland.

Ship.	Compass.	Place.	Date.	Approximate coefficients. A	B	C	D	E	Exact coefficients. A	B	C	D	E
NORTHUMBERLAND (*continued*).	Starboard steering.	On stocks	Mar. and Apr. 1866	° ′	° ′	° ′	° ′	° ′		−·846	+·499	+·105a	.....
										−·855	+·491	+.117a	.....
		Off Deptford	April 19, 1866	*By deviation and forces on one point*						−·882	+·455	+·105a	.....
										−·874	+·447	+·117a	.....
		In Victoria Docks.	April 21, 1866						.....	−·761	+·150	+·105a	.....
			May 29, 1866	*By deviation and force on one point (head S. 22° W. magnetic). Two iron-plated ships alongside steam machinery, iron masts, &c. placed on board during this interval.*						−·635	+·018	,,	.....
			July 12, 1866							−·760	−·108	,,	.....
			Aug. 10, 1866							−·726	+·022	,,	.....
			Sept. 1, 1866							−·740	−·071	,,	.....
			Oct. 24, 1866							−·668	−·107	,,	.....
			Dec. 17, 1866							−·651	−·089	,,	.....
		Sheerness	Jan. 1, 1867	+0 09	−39 50	+15 18	+ 6 39	+ 0 42	+·003	−·683	+·232	+·116	+·012
		Sheerness	*Jan.* 26, 1867	−0 24	− 2 37	+38 19	+ 6 24	− 0 20	−·007	−·046	+·596	+·112	−·006
		Sheerness	*Feb.* 28, 1867	+0 41	− 5 20	+40 41	+ 6 28	+ 2 40	+·012	−·098	+·625	+·113	+·046
			Mar. 2, 1867	**−0 18**	**−4 15**	**−1 04**	**+6 42**	**+1 44**	**−·005**	**−·078**	**−·018**	**+·117**	**+·030**
		Devonport	*Aug.* 29, 1867	*By deviation and forces on one point*					...	−·229	+·637	+·110a	.....
		Devonport	*Dec.* 10, 1867	*Ship in dock (head S. 84° E. magnetic)*					...	−·136	+·641	+·110a	.....
		Devonport	*Dec.* 10, 1867	.....	.....	.....	.....	.....	...	−·141	·+617	+·127a	.....
	Port steering.	Sheerness	Jan. 1, 1867	+1 13	+43 0	+19 48	+ 6 18	− 0 28	+·021	−·725	+·302	+·110	−·008
		Sheerness	*Jan.* 26, 1867	−0 39	− 4 13	−10 52	+ 7 40	− 2 11	−·011	−·078	−·176	+·133	−·038
		Sheerness	*Feb.* 28, 1867	+0 53	− 3 55	− 7 50	+ 6 54	− 0 12	+0·15	−·071	−·128	+·120	−·003
		Devonport	*Aug.* 29, 1867	*By deviation and forces on one point*					...	−·176	+·150	+·110a	
		Devonport	*Dec.* 10, 1867	*Ship in dock (head S. 84° E. magnetic)*					...	−·212	+·508	.....	
		Devonport	*Dec.* 10, 1867	.....	.....	.....	.....	.....	...	−·218	+·481	+·127	
	Lower deck.	Sheerness	Feb. 28, 1867	−0 11	− 3 23	+11 05	+13 02	+ 0 32	−·003	−·065	+·170	+·228	+·009
		Devonport	Aug. 29, 1867	*By deviation and forces on one point*					.....	−·025	+·333	+·220	
		Devonport	Dec. 10, 1867	*Ship in dock (head S. 84° E. magnetic)*					.....	−·082	+·412	+ 220	

Note.—The coefficients marked (a) are assumed values.

General Table (continued).—Her Majesty's Ship Northumberland.

Maximum of semicircular deviation / Mean Horizontal force of ship $\sqrt{\mathfrak{B}^2+\mathfrak{C}^2}$†.			Mean force to North, λ ‡	$\frac{1}{\lambda}$	Coefficients of horizontal induction.		Part of $\mathfrak{D}$ from		Mean vertical force, μ §	Heeling coefficient to *windward*.	Heeling coefficient for		Variable part of vertical force.	
					Headward. a ‡	To starboard. e ‡	Fore-and-aft induction.	Transverse induction.			Vertical induction in transverse iron.	Vertical force and induction in vertical iron.	$\frac{g}{\tan\theta}$ §	g ‡
Amount.		Direction.												
°		°					° ′	° ′		° ′	° ′	° ′		
77½	·976	149¾	·800a	.....	.....	.....	.....	.....	1·186	+1 28	.....	.....	+·100a	
79¾	·984	150¼							1·259	+1 43	.....	.....	−·005a	
84¼	·995	152½	·800a	.....	.....	.....	.....	.....	1·296	+1 49	.....	.....	+·100a	
78¾	·984	153							1·221	+1 36	.....	.....	−·005a	
51	·777	168½	·800a	.....	.....	.....	.....	.....	1·126	+1 17	.....	.....	+·100a	
39½	·635	178½	,,	.....	.....	.....	.....	.....	1·163	+1 24	.....	.....	,,	
50	·767	188¼	,,	.....	.....	.....	.....	.....	·996	+0 58	.....	.....	,,	
46½	·726	178½	,,	.....	.....	.....	.....	.....	·821	+0 37	.....	.....	,,	
48¼	·744	185½	,,	.....	.....	.....	.....	.....	·935	+0 40	.....	.....	,,	
42½	·676	189	,,	.....	.....	.....	.....	.....	·949	+0 43	.....	.....	,,	
41	·657	188	,,	.....	.....	.....	.....	.....	·924	+0 39	.....	.....	,,	
46¼	·721	161¼	·802	1·247	−·105	−·291	−3 45	+10 24	1·056	+1 04	+0 54	+0 10	−·005	−·012
36¾	·598	94½	·783	1·277	−·105	−·304	−4 43	+11 12	1·250	+1 45	+0 57	+0 47		
39¼	·630	97												
4½	·080	193	·841	1·189	−·064	−·254	−2 11	+ 8 39	1·285	+1 35	+0 45	+0 50	+·041	+·102
42¾	·678	110	·820a	.....	.....	.....	.....	.....	1·114	+1 10	.....	.....	,,	
40	·655	102	,,		.....	.....	.....	.....	1·036	+0 56	.....	.....	,,	
39¼	·633	103	·800a											
51	·786	157¼												
11	·193	246												
8¼	·146	241												
13¼	·231	139½	·820a	.....	.....	.....	.....	.....	1·255	+1 36	.....	.....	,,	
33½	·550	112½	,,	.....	.....	.....	.....	.....	1·102	+1 08	.....	.....	,,	
31¾	·527	114	·800a											
10½	·182	111	·729	1·371	−·105	−·437	−4 05	+17 24						
19½	·334	94	·740a											
24¾	·420	101	,,											

$$a = \lambda\mathfrak{D} - (1-\lambda).$$
$$e = -\lambda\mathfrak{D} - (1-\lambda).$$

Part of $\mathfrak{D}$ from { Fore-and-aft induction $= \frac{a}{2\lambda} = \frac{\mathfrak{D}}{2} - \left(\frac{1}{\lambda} - 1\right)$. Transverse induction $= -\frac{e}{2\lambda} = \frac{\mathfrak{D}}{2} + \left(\frac{1}{\lambda} - 1\right)$.

Heeling coefficient to *windward* $= \left(\mathfrak{D} + \frac{\mu}{\lambda} - 1\right)\tan\theta$.

Part of heeling coefficient. { from Vertical induction in transverse iron ..... $= \left(\mathfrak{D} + \frac{1}{\lambda} - 1\right)\tan\theta$. from Vertical force and Vertical induction in Vertical iron ..... $= \left(\frac{\mu}{\lambda} - \frac{1}{\lambda}\right)\tan\theta$.

† Mean force to North (λH) being unit. ‡ Earth's Horizontal force (H being unit). § Earth's Vertical force (Z) being unit.

H.M.S. NORTHUMBERLAND.

Figure 1.

Plan.

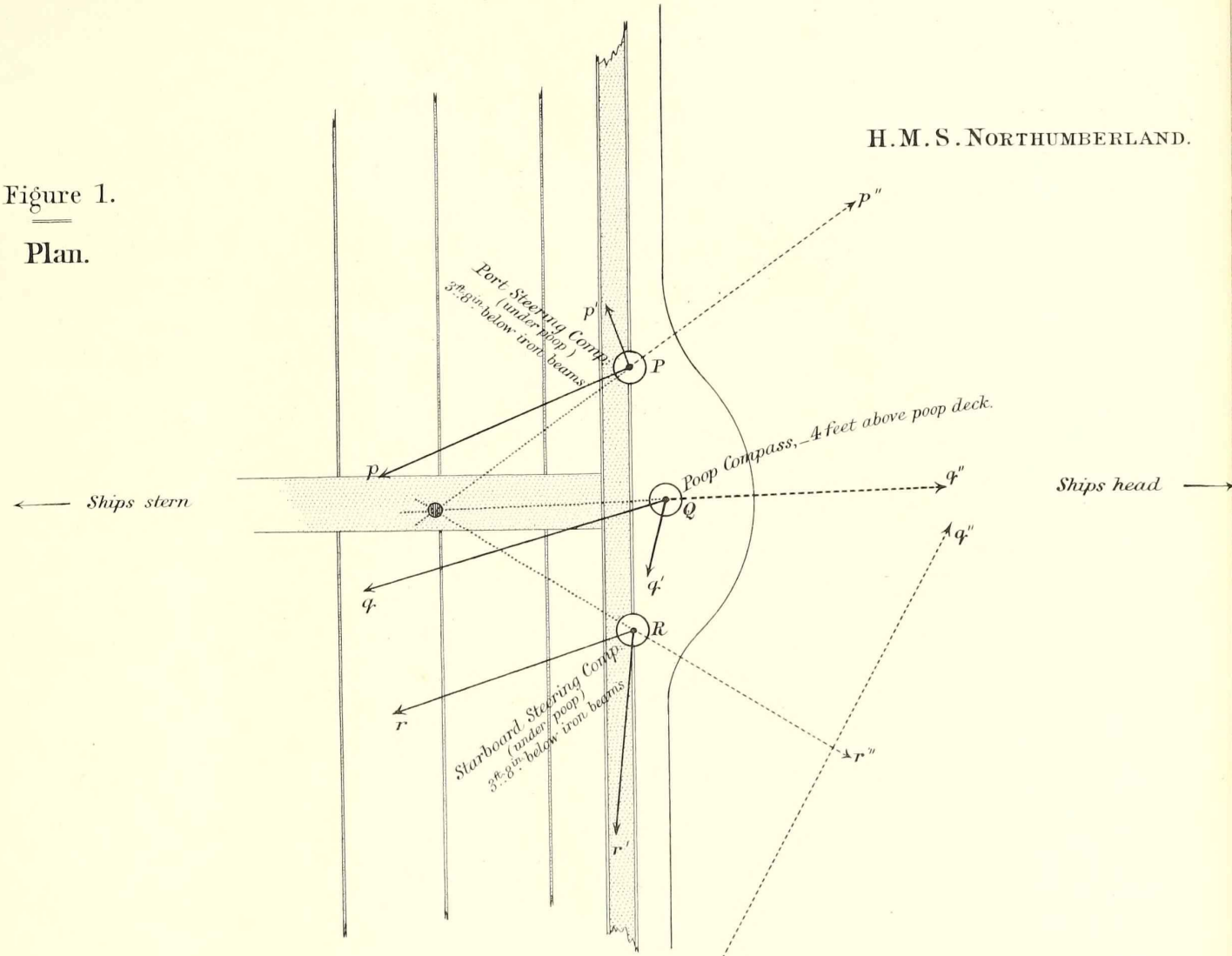
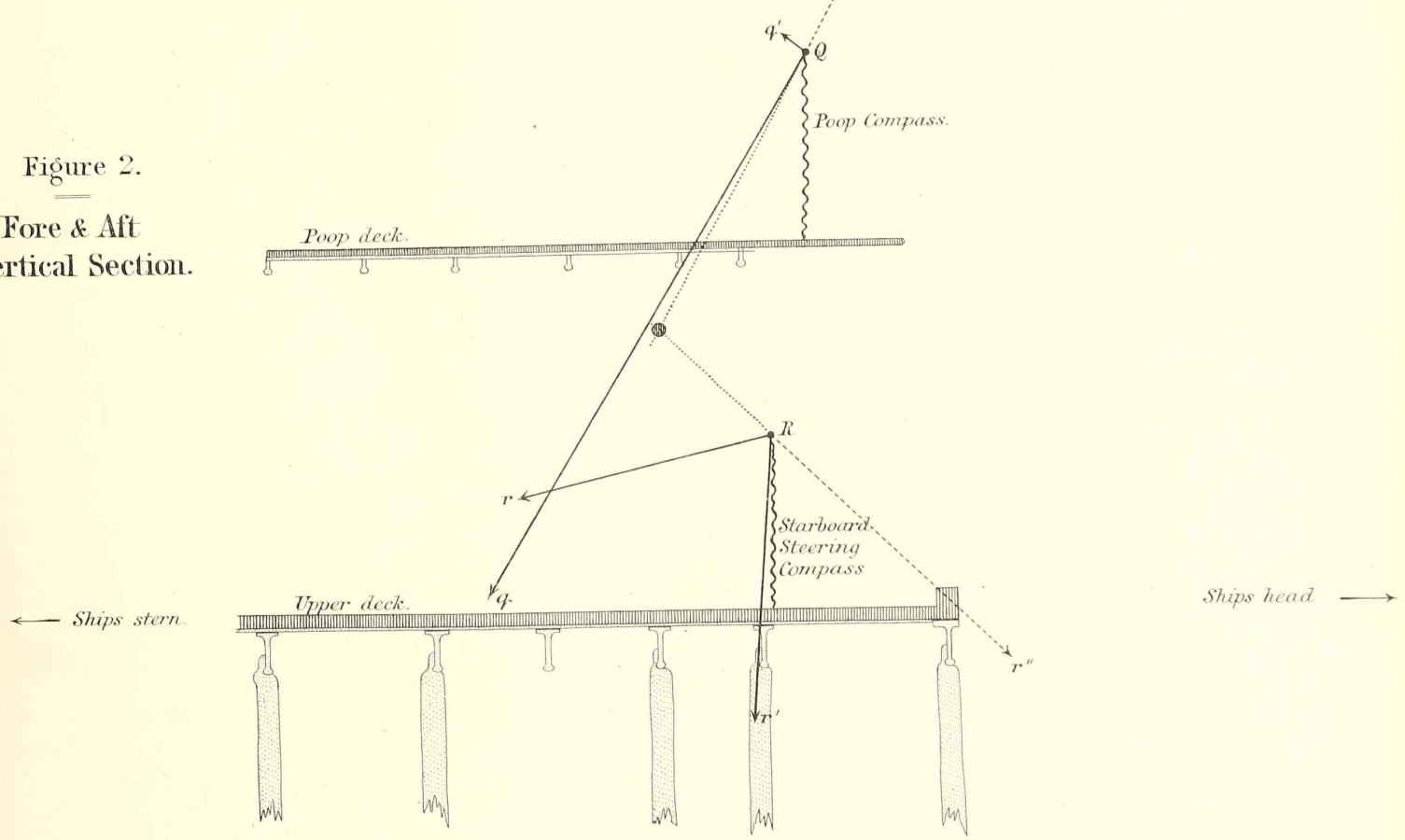


Figure 2.

Fore & Aft Vertical Section.



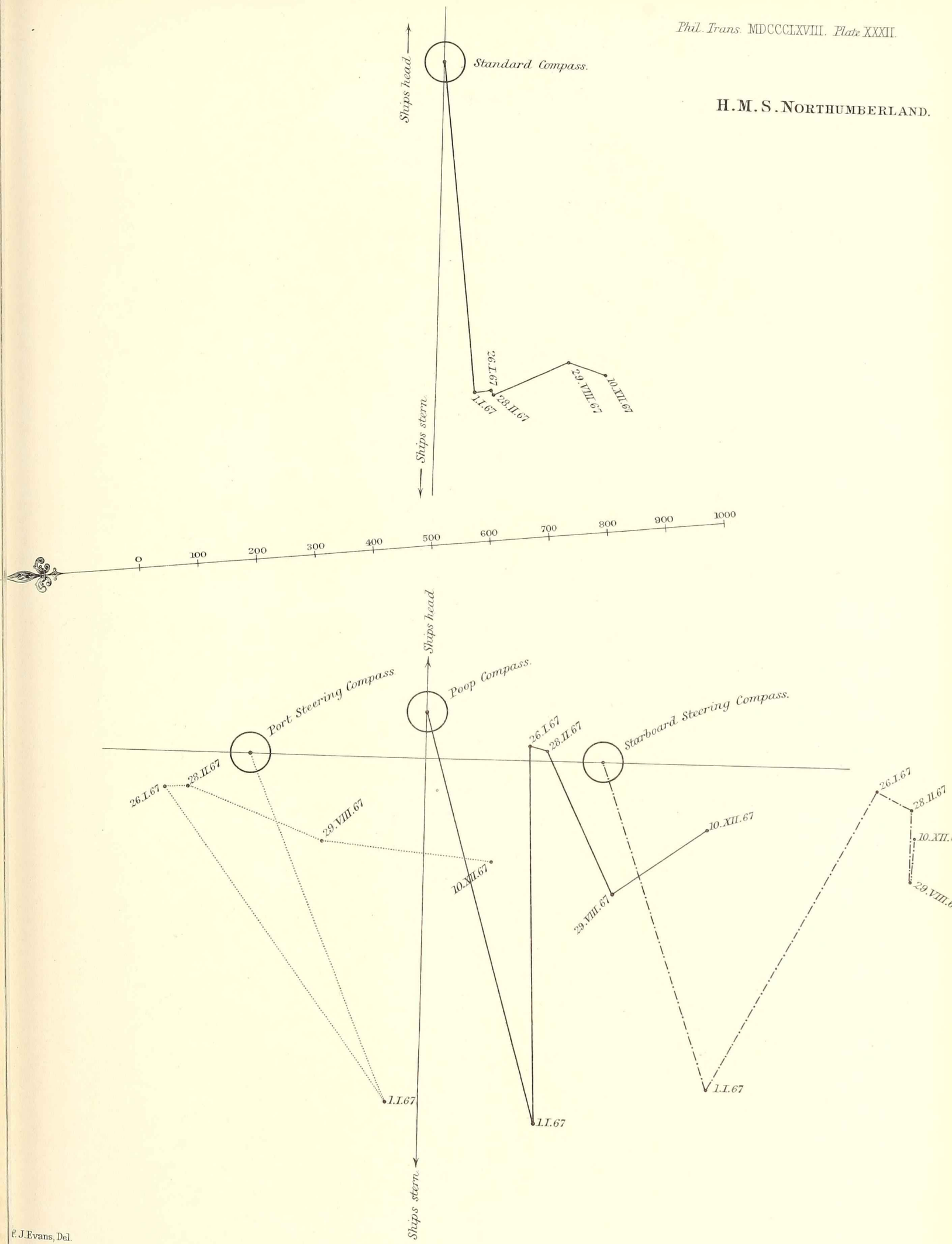
0 1 2 3 4 5 6 7 8 9 10 15 20

Scale of Feet, and also of 10ths. of Earth's horizontal force.

F. J. Evans, Del.

Malby & Sons, Lith.

H.M.S. Northumberland.



F. J. Evans, Del.

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XX. *Contributions towards determining the Weight of the Brain in different Races of Man.* *By* Joseph Barnard Davis, *M.D., &c.* *Communicated by* J. Marshall, *Esq., F.R.S.*

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The Brain being the most essential and characteristic portion of the human organization, as connected with intelligence and mental manifestations, it would naturally be expected to have absorbed great attention. Still, comparatively little has been done to ascertain its relative magnitude in the different races of mankind. Opportunities for the examination of exotic brains are very rare; and it is only by gauging the capacities of trustworthy skulls of different races, and thence deducing the volume of the encephalon that extended and reliable data are to be obtained. That an accumulation of observations of this kind is required for any results deserving confidence, ensues from the manifest diversity of volume and weight which pervades all individual organs of the body. These skulls are but seldom met with in such variety and such number as to yield satisfactory data. Hence it seems to be very desirable to place on record the averages calculated for a considerable collection of human crania, embracing most of the chief divisions of mankind.

It may be supposed that this method is inferior to that of ascertaining directly the weight of the brain. This, however, is itself subject to considerable fluctuations, dependent upon sex, age, the kind of disease with which the person has been affected, and the condition of the organ at the period of death*. These all influence the determination, and complicate the deduction of any average weight and volume of the brain when subjected to the manipulation of the observer. It has been asserted "that the actual weights of human brains can alone form just data for conclusions; and that it seems scarcely possible that any method of ascertaining the size of the brain from examination of the skull can be free from fallacy"†. Without undervaluing the views of so excellent an observer as Dr. Peacock, it may be said that, if this be allowed to be correct in reference to any individual case, since the disease which terminates the life of a person itself alters the relation of the solid to the fluid contents of the cranium, it may yet with confidence be affirmed that the examination of a large series of skulls in ascertaining their

* Chronic diseases tend to change the proportions between the weight of the brain and the fluids of the cranium. These fluids are abundant at an early period of life, diminish from birth to a mature age, from twenty to thirty years of age, after which they again increase. Dr. A. Weisbach, in his careful observations, found the fluids more abundant in the brains of men than in those of women.

† Dr. Thomas B. Peacock, 'Tables of the Weights of the Brain and of some other Organs of the Human Body,' 1861, p. 22. Reprinted from the 'Monthly Journal of Medical Science,' vol. vii. 1847.

capacities and deducing from those capacities the average volume of the brain, affords, in some respects, more available data for determining this relative volume for any particular race than the weighing of the brain itself. It might be less easy in this way to fix the exact weight of any individual encephalon, which might be much changed by some lingering and wasting disease (a large portion of Dr. PEACOCK'S cases died of Phthisis); but, practically, this method is more sure to yield an accurate average size of the organ, because we have it in our power to use an unchangeable substance with which to gauge the capacity of the skull. And we thus arrive at conclusions the same in result as if we had the brain in all skulls at a uniform density, which, in fact, is the true basis of comparison.

The method followed in the present researches has been to fill each skull, as uniformly as possible, with clean and dry Calais sand of a definite specific weight, 1425*. Then to pour out the sand, and weigh it carefully. The great difficulty which has always stood at the threshold of ascertaining the volume of the brain from the mere internal capacity of a skull, has arisen from the necessity for, and the variable mode of, making allowance for the other contents of the cranium besides the encephalon, and the uncertainty of the proper amount of such allowance in each special case. This difficulty being once overcome and a uniform rate of allowance being fixed upon a reliable basis, it will be almost as satisfactory in all investigations of this kind to obtain the weight of the brain by gauging the capacity of the skull as by weighing the encephalon itself.

In order to get the proper allowance, or *tare*, to be deducted from the weight of sand which filled the cranium, as a compensation for the weight of the dura mater, the fluids of the membranes and ventricles, and also of the blood contained in the large vessels (after much inquiry and deliberation and consulting the best information to be got upon the absolute weight of the membranes and fluids of the human brain), it has been decided to allow a proportionate or percentage deduction as a tare upon the capacity of the skull and its contents; and this deduction has been fixed at 15 per centum. By this means the allowance will vary in exact proportion to the size of the brain itself, increasing as this increases. And when we come to compare the brain-weights acquired by different observers from actual metrological experiments with the results obtained by such a uniform deduction of 15 per cent. they will be found to agree upon the whole accurately†.

The weight of the sand, after this deduction of 15 per cent., has then to be converted into its equivalent of cerebral matter of the specific gravity of 1040, which is the nearest average datum carefully determined by different competent observers‡.

* The weight of a given bulk of dry Calais sand, moderately shaken down, is, to distilled water, as 1425 to 1000.

† In the 'Crania Britannica,' p. 224, Note *, it was proposed to allow 5 ounces av. in the skulls of men, and 4·5 oz. in those of women. This was the result of some observations made by Dr. THURNAM.

‡ In a subsequent part of this memoir a reference will be made to actual metrological experiments on individual brains, where the cranial capacity has likewise been determined, when it will be seen that the results

It has already been stated that the 15 per centum tare is intended to cover the weight of the dura mater and pia mater, the arachnoid, the fluids of these membranes and of the ventricles, and also of the blood contained in the large vessels. This weight altogether is considerable. Professor MARSHALL has made the following explanatory remarks. "If the brain, in its natural state, filled the cranial cavity as completely as water will afterwards, it would be easy, by taking the specific gravity of nervous substance as compared with water, to estimate the quantity of brain which once occupied any given skull; but the fact that this is not the case, especially in regard to the base of the brain, and the difficulty in determining the weight of the membranes, the amount of blood which the vessels may contain, and the quantity of cerebro-spinal fluid which fills the ventricles and all otherwise unoccupied spaces, render it impossible thus to arrive at so definite an estimate as in the other way," *i. e.* by weighing the encephalon*.

The present may be regarded as the first attempt to deduce with accuracy the weight of the brain from the capacity of the skull, on any commensurate scale. Professor TIEDEMANN'S and Professor MORTON'S crude observations are of small value in this respect, and the attempts of others have been very limited and uncertain. It is remarkable that neither of these two accomplished men made any allowance in their observations for the membranes and fluids. This might not be deemed necessary in the comparison of the relative size of the cranial cavity in different races, aimed at by the former, who, when he subjected the brain to the weighing process, divested it of the arachnoid and the pia mater. The latter observer might seem to have overlooked the need of any allowance; at all events, in his Memoir†, he tells us that by his process of gauging the cavity of the skull with leaden shot, "I thus obtain the absolute capacity of the cranium, or bulk of the brain, in cubic inches;" and he describes his great Table as "showing the size of the brain in cubic inches"—whereas, in fact, it merely gives the capacity of 623 crania in cubic inches. It is quite needless to endeavour to prove that an allowance for membranes and fluids is absolutely necessary.

Attempts have been made by different observers to determine the proportion in weight by which the brains of men exceed those of women. This appears to be variable, and possibly the variation may be in relation to particular races; but to decide this question would require materials of a very exact nature. The proportion differs from about 5 per cent. in our Australians, to more than 10 per cent. in our Tasmanians. It may be said generally in our series to range from less than 10 per cent. to something more than $12\frac{1}{2}$ per cent., so that the proposal of Professor WELCKER to regard it as 10 per cent. may for the present be as safe as any other.

When Professor TIEDEMANN considered as the result of his investigation, that he was

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closely coincide. For reasons already given, it is apparent that no rule can be formed which shall agree with all individual cases.

* JOHN MARSHALL, F.R.S., "On the Brain of a Bushwoman," &c., Philosophical Transactions, 1864, p. 506.

† Proceedings of the Academy of Natural Sciences of Philadelphia, October 1849.

justified in making the assertion, which he said could not be regarded as a hypothesis, that Nature, inasmuch as a certain size and mass of brain is a necessary condition for the exercise of the faculties of the mind, hath furnished the people of all human races herewith in an equal degree, he was compelled to have recourse to a series of secondary influences to account for the diverse intellectual state of mankind. It was the hypothetical error of his system that led him to insist on the physical unity of man; his intellectual inequality could not be denied*. On the other hand, Professor HUSCHKE affirmed that a difference in the weight of the brain in different races cannot be mistaken, with which the stature may correspond. He adds, thus the German brain exceeds in the mean 1400 grammes, the French has been by many observers specified to be only 1300 grammes, and that of the small Hindoos and indigenes of Bombay amounts to only 1000 to 1100 grammes†. It will be easier to test the correctness of these and various other statements, after our Tables have been examined.

The importance of the average stature and weight of the body, so variable in different races, in their relations to the size and weight of the brain, although these relations have not yet been properly investigated, has not been overlooked. The large Germans and the small Hindoos are obvious instances. Up to the present time, exact observations upon the stature and weight of the races of man are almost wholly wanting. The notes to the Tables will include some information upon these points, in the cases in which it can be obtained.

The weight of the brain is much influenced by sex and by age. In the following Tables the sexes of the crania have been determined, as accurately as may be from their examination, where they have not been otherwise known. They are always distinguished in their relative numbers. This was omitted in MORTON'S Table, as may be mentioned with regret. The observations have been confined to the skulls of *adults*. Any more definite rule respecting age it was not easy to lay down. The brain-weights have been arranged in six Tables, corresponding very much with the races of the six great divisions of the globe. In all cases, the estimated weight of the heaviest brain of the series is given first, then that of the lightest, and last the average weight of the whole. By the insertion of the averages of each sex and of the whole series, as much is done as may be to correct the preponderance of those individual exceptional cases of large brains, *megalocephali*, and small brains, *microcephali*, which occur in probably all races of man.

In general it has not been thought necessary to exclude from our estimates either synostotic or artificially distorted skulls. The effects of synostosis are almost always much confined to limiting the development of the cranial cavity *in one direction*, whilst it has received a corresponding expansion in another compensatory direction; so that there is no material diminution in the mass of the cerebral matter contained in the skull. In the cranium of the Stettin Weaver, the most remarkable example of syno-

* Professor TIEDEMANN'S Memoir was read before the Royal Society in 1835, and appears in the Philosophical Transactions, vol. cxxvii. The reference is here made to the German edition, Das Hirn des Negers mit dem des Europäers und Orang-Outangs verglichen, 1837, S. 47.

† Schædel, Hirn und Seele des Menschen und der Thiere, 1854, S. 60.

stotic deformation recorded, the internal capacity is not materially interfered with*. There are exceptional cases, as those in which most of the sutures are simultaneously ossified at a very early period of life, producing a limited growth of the brain in the whole mass, and constrained microcephalism†. Artificial distortion of the skull also acts in a similar manner; it arrests development in one direction, which is compensated for by increased growth in another. This mainly corresponds with the evidence of all the best observers, as MORTON and CATLIN, that individuals with the most frightfully compressed heads, speaking in ordinary terms, are in every respect equal in intellectual power to those whose heads have undergone no distortion. But this must not be allowed to affect the question, whether those with distorted crania, either from synostosis or by art, are not more prone to moral perversions, and more frequently the subjects of mental aberration than others‡.

In the Notes to the following Tables it is intended to add and to collate observed weights of brains, where they have been ascertained, with the weights deduced, so as to compare, authenticate, and correct the computed results.

As already said, the *heaviest* brain-weights are given first, the *lightest* next, and then the *average*, which is obtained by adding the special weights of all the examples of either sex together, and dividing by the number of individual specimens. The *mean of the sexes* is obtained by adding the average of the males and that of the females together, and dividing by two. The *mean of the series* is obtained by adding the particular weights of all the examples of both males and females together, and dividing by the number of specimens. This is a convenient mean, but must be taken subject to some variation, according to the relative proportion of the examples of the one sex to those of the other. In general, the males greatly exceed the females in number; in some cases, as in the French, the Vedahs, the Cingalese, and the Hindoos, the sexes are almost equal; in the Esquimaux of Greenland and in the Caribs, they are exactly so; and in the Irish and Guanches there is a preponderance in the number of the skulls of women§.

* On Synostotic Crania among Aboriginal Races of Man. J. BARNARD DAVIS, 1865. Plates 9, 10, and 11. Transactions of the Dutch Society of Sciences of Haarlem.

† Ibid. p. 21. ‡ Ibid. p. 22.

§ There are many other important queries suggested by these Tables, such as the exact origin of the skulls themselves, what particular portions of the different countries they are derived from, their authenticity, and other questions which cannot be introduced here. They are all more or less fully illustrated in an octavo volume just issued, entitled 'Thesaurus Craniorum. Catalogue of the Skulls of the Various Races of Man in the Collection of JOSEPH BARNARD DAVIS, M.D.' London 1867.

Tables of the Computed Weights of the Brains contained in Skulls of People of different Races.

(Expressed in Avoirdupois Ounces, and in Grammes.)

Table I.—EUROPEAN RACES.

Races.	1.	Brain-weights of the Skulls of Men.						8.	Brain-weights of the Skulls of Women.						Mean of Sexes.		Mean of Series.		19.
		2.	3.	4.	5.	6.	7.		9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	
	Number.	Heaviest.		Lightest.		Average.		Number.	Heaviest.		Lightest.		Average.						Mean internal capacity.
		oz. av.	grms.	oz. av.	grms.	oz. av.	grms.		oz. av.	grms.	oz. av.	grms.	oz. av.	grms.	oz. av.	grms.	oz. av.	grms.	cub. inch.
1. Ancient Britons	56	57·07	1617	40·94	1160	52·54	1489	10	45·32	1285	39·70	1125	43·27	1226	47·90	1357	45·83	1299	89·8
2. Ancient Scottish	3	48·16	1365	38·82	1100	43·30	1227	2	44·66	1266	42·18	1195	43·42	1230	43·36	1229	43·42	1230	85·1
3. Ancient Romano-Britons	44	63·49	1795	39·70	1125	47·80	1355	12	45·68	1295	31·67	897	41·45	1175	44·62	1264	45·97	1303	90·1
4. Anglo-Saxons	39	54·59	1547	40·95	1160	47·07	1334	16	47·14	1336	36·63	1038	41·67	1181	45·61	1293	45·46	1288	89·1
5. English	21	57·43	1628	44·08	1249	50·28	1425	13	49·62	1406	37·22	1055	43·13	1222	46·70	1323	47·50	1346	93·1
6. Irish	12	62·03	1758	39·48	1119	49·62	1406	16	52·54	1489	38·46	1090	44·51	1261	47·06	1334	46·70	1323	91·5
7. Merovingian Franks	4	51·89	1471	48·75	1382	50·28	1425	...	.....	.....	.....	.....	.....	.....	.....	.....	50·28	1425	98·5
8. French	9	52·10	1477	42·18	1195	47·21	1338	7	47·14	1336	38·46	1090	42·54	1206	44·87	1272	45·17	1280	80·4
9. Spaniards and Portuguese	7	50·35	1427	45·68	1295	48·31	1369	...	.....	.....	.....	.....	.....	.....	.....	.....	48·31	1369	94·7
10. Ancient Romans of Italy	8	54·37	1541	41·96	1189	47·14	1336	...	.....	.....	.....	.....	.....	.....	.....	.....	47·14	1336	92·4
11. Italians	13	52·10	1477	42·18	1195	48·24	1367	2	45·03	1276	40·06	1135	42·54	1206	45·39	1286	47·58	1348	93·3
12. Lapps	5	54·00	1530	45·68	1295	47·65	1350	2	44·59	1264	44·59	1264	44·59	1264	46·14	1308	46·19	1309	90·5
13. Swedes	9	51·59	1462	47·14	1336	49·11	1392	3	47·14	1336	42·18	1195	44·22	1253	46·66	1322	47·94	1359	94
14. Frisians	3	54·00	1530	45·39	1286	48·60	1377	...	.....	.....	.....	.....	.....	.....	.....	.....	48·60	1377	95·3
15. Dutch	18	54·00	1530	39·70	1125	49·55	1404	7	43·42	1230	40·94	1160	41·96	1189	45·75	1296	47·36	1342	92·8
16. Germans	13	55·83	1582	47·14	1336	52·83	1499	2	41·60	1179	40·35	1143	40·94	1160	46·88	1329	50·28	1425	98·5
17. Russniak	1	52·76	1495	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	52·76	1495	103·4
18. Poles	2	47·14	1336	47·14	1336	47·14	1336	...	.....	.....	.....	.....	.....	.....	.....	.....	47·14	1336	92·4
19. Czechs	2	52·76	1495	41·60	1179	47·14	1336	...	.....	.....	.....	.....	.....	.....	.....	.....	47·14	1336	92·4
20. Magyar	1	45·03	1276	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	45·03	1276	88·5
21. Slovak	1	43·78	1241	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	43·78	1241	85·8
22. Finns	7	50·86	1441	46·56	1319	48·31	1369	...	.....	.....	.....	.....	.....	.....	.....	.....	48·31	1369	94·7
23. Russians	10	57·07	1617	44·66	1266	50·28	1425	...	.....	.....	.....	.....	.....	.....	.....	.....	50·28	1425	98·5
24. Turks	3	50·28	1425	45·90	1301	47·58	1348	...	.....	.....	.....	.....	.....	.....	.....	.....	47·58	1348	93·3
25. Rumanyos	6	52·23	1480	44·66	1266	45·97	1303	...	.....	.....	.....	.....	.....	.....	.....	.....	45·97	1303	90·1
26. Gipsies	2	45·02	1276	42·84	1214	43·93	1245	2	44·44	1259	41·96	1189	43·20	1224	43·56	1234	43·41	1230	85·1
Numbers and Averages	299	52·68	1493	43·61	1236	48·25	1367	94	46·02	1304	39·56	1121	42·49	1204	45·73	1296	47·12	1335	92·3

Table II.—ASIATIC RACES.

1. Vedahs of Ceylon	3	57·58	1632	39·69	1125	45·51	1290	5	45·03	1276	34·75	985	39·33	1115	42·42	1202	41·23	1168	80·8
2. Cingalese	6	52·76	1495	38·45	1090	47·21	1338	5	46·56	1320	36·61	1037	42·98	1218	45·09	1278	45·32	1284	88·6
3. Afghans	4	58·96	1671	40·35	1148	45·32	1285	3	38·46	1090	36·63	1038	37·65	1067	41·48	1175	42·11	1193	82·5
4. Hindoos	35	51·52	1460	36·63	1038	44·22	1253	31	47·80	1355	33·49	949	39·99	1133	42·10	1193	42·11	1193	82·5
5. Mussulmans	14	52·76	1495	37·87	1073	44·66	1266	7	46·56	1320	39·11	1108	41·60	1179	43·13	1222	43·57	1235	85·4
6. Khōnds	2	38·46	1090	37·22	1015	37·87	1073	...	.....	.....	.....	.....	.....	.....	.....	.....	37·87	1073	74·2
7. Gōnd	1	40·72	1159	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	40·72	1159	79·8
8. Lepchas	7	49·62	1406	39·11	1108	45·90	1301	6	49·03	1390	37·87	1073	42·03	1191	43·96	1246	44·08	1249	86·4
9. Bodos	4	50·28	1425	42·18	1195	46·92	1330	7	48·38	1371	42·18	1195	45·32	1284	46·12	1307	45·97	1303	90·1
10. Bhotias	4	53·34	1512	42·18	1195	46·78	1326	9	52·47	1487	37·22	1055	43·85	1243	45·31	1284	45·90	1301	90
11. Mishmees	3	50·28	1425	44·08	1249	47·36	1342	...	.....	.....	.....	.....	.....	.....	.....	.....	47·36	1342	92·8
12. Singpho	1	47·87	1357	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	47·87	13 7	93·8
13. Nagas	2	50·28	1425	45·32	1284	47·80	1355	...	.....	.....	.....	.....	.....	.....	.....	.....	47·80	1355	93·7
14. Siamese	4	50·28	1425	47·16	1337	48·95	1387	3	48·38	1371	39·11	1108	44·88	1272	46·91	1329	47·14	1336	92·4
15. Chinese	25	57·07	1617	43·42	1231	47·87	1357	8	49·99	1417	37·87	1073	43·71	1239	45·79	1298	47·00	1332	92·1
16. Burmese	5	50·28	1425	45·90	1301	47·87	1357	...	.....	.....	.....	.....	.....	.....	.....	.....	47·87	1357	93·8
17. Japanese	1	45·25	1282	.....	.....	.....	.....	1	35·39	1003	.....	.....	.....	.....	40·32	1143	40·32	1143	79
18. Aïnos	3	47·65	1350	44·08	1249	45·90	1301	1	43·42	1231	.....	.....	.....	.....	44·66	1266	45·83	1299	89·7
Numbers and Averages	124	50·27	1425	41·57	1178	46·00	1304	86	45·95	1302	37·48	1062	42·13	1194	43·94	1245	44·44	1259	87·1

Table III.—AFRICAN RACES.

1. Berbers	...	.....	.....	.....	.....	.....	.....	4	48·38	1371	40·35	1148	43·42	1231	.....	.....	43·42	1231	85·1
2. Guanches	3	48·38	1371	42·18	1195	45·32	1284	18	49·62	1406	39·11	1108	43·13	1222	44·22	1253	43·49	1233	85·2
3. Negroes of Tribes unknown	12	54·00	1530	40·94	1160	44·30	1255	4	45·32	1284	37·00	1048	43·49	1230	43·89	1244	44·08	1249	86·4
4. Joloff	1	46·92	1330	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	46·92	1330	92
5. Foulah	1	43·42	1231	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	43·42	1231	85·1
6. Mandingoes	1	47·14	1336	.....	.....	.....	.....	1	34·15	968	.....	.....	.....	.....	40·64	1152	40·64	1152	79·6
7. Serryia	1	46·92	1330	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	46·92	1330	92
8. Fantees	1	41·60	1179	.....	.....	.....	.....	1	39·11	1108	.....	.....	.....	.....	40·35	1143	40·35	1143	79·1
9. Ashantees	3	47·00	1332	39·70	1125	42·91	1216	...	.....	.....	.....	.....	.....	.....	.....	.....	42·91	1216	84·1
10. Dahomans	9	50·28	1425	40·94	1160	46·63	1322	3	47·80	1355	42·18	1195	44·08	1249	45·35	1285	46·34	1313	90·8
11. Eboes	...	.....	.....	.....	.....	.....	.....	4	43·42	1231	40·35	1143	41·74	1183	.....	.....	41·74	1183	81·8
12. Yorubans	...	.....	.....	.....	.....	.....	.....	4	49·04	1390	40·35	1143	45·46	1288	.....	.....	45·46	1288	89·1
13. Akassa	1	44·08	1249	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	44·08	1249	86·4
14. Bakeles	2	52·76	1495	48·39	1371	50·57	1433	5	51·23	1452	40·94	1160	46·08	1306	48·32	1369	46·41	1315	91
15. Osyekanis	1	48·16	1365	.....	.....	.....	.....	5	45·32	1284	35·76	1013	37·58	1065	42·86	1215	41·89	1187	82·1
16. M'Pongwe	1	46·56	1319	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	46·56	1319	91·2
17. Asango	...	.....	.....	.....	.....	.....	.....	1	34·15	968	.....	.....	.....	.....	.....	.....	34·15	968	66·9
18. Asira	1	45·90	1301	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	45·91	1301	90
19. M'Fans	...	.....	.....	.....	.....	.....	.....	3	45·90	1301	42·18	1195	43·85	1243	.....	.....	43·85	1243	85·9
20. Congos	2	40·35	1143	39·18	1110	39·76	1127	...	.....	.....	.....	.....	.....	.....	.....	.....	39·76	1127	77·9
21. Manganja	1	52·76	1495	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	52·76	1495	103·4
22. Hottentots	...	.....	.....	.....	.....	.....	.....	3	42·84	1216	39·69	1125	41·86	1187	.....	.....	41·86	1187	82
23. Kafirs	7	53·34	1512	39·70	1130	49·04	1390	1	41·60	1179	.....	.....	.....	.....	47·47	1345	48·16	1365	94·4
24. Zulus	4	50·28	1424	44·52	1262	46·56	1319	...	.....	.....	.....	.....	.....	.....	.....	.....	46·56	1319	91·2
25. Bushmans	1	40·35	1143	.....	.....	.....	.....	3	40·78	1156	37·22	1055	39·48	1119	39·91	1131	39·70	1125	77·8
Numbers and Averages	53	47·37	1342	41·93	1188	45·63	1293	60	43·91	1244	39·59	1122	42·74	1211	43·66	1237	43·89	1244	86

TABLE IV.—AMERICAN RACES.

Races.	1.	Brain-weights of the Skulls of MEN.						8.	Brain-weights of the Skulls of WOMEN.						Mean of Sexes.		Mean of Series.		19.
		2.	3.	4.	5.	6.	7.		9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	
	Number.	Heaviest.		Lightest.		Average.		Number.	Heaviest.		Lightest.		Average.						Mean internal capacity.
		oz. av.	grms.	oz. av.	grms.	oz. av.	grms.		oz. av.	grms.	oz. av.	grms.	oz. av.	grms.	oz. av.	grms.	oz. av.	grms.	cub. inch.
1. Esquimaux of Greenland ...	5	57·72	1636	47·14	1336	49·25	1396	5	49·03	1390	37·22	1055	44·00	1247	46·62	1321	46·56	1319	91·2
2. Esquimaux, Eastern	4	49·62	1406	42·85	1214	46·23	1310	1	47·14	1336	.....	.....	.....	.....	46·68	1323			
3. Esquimaux, Western	4	47·14	1336	44·15	1251	45·39	1286	2	43·42	1230	41·30	1170	42·36	1200	43·87	1243	45·90	1301	90
4. Iroquois	1	45·90	1301	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	44·66	1266	87·5
5. Mississaga	...	.....	.....	.....	.....	.....	.....	1	44·66	1266	.....	.....	.....	.....	.....	.....	44·08	1249	86·4
6. Athabasca	...	.....	.....	.....	.....	.....	.....	1	44·08	1249	.....	.....	.....	.....	.....	.....	48·72	1382	95·5
7. Shushwaps	1	50·53	1432	.....	.....	.....	.....	1	46·92	1330	.....	.....	.....	.....	48·72	1382	48·72	1382	95·5
8. Chemesyans	2	50·86	1441	41·60	1179	46·23	1310	1	42·47	1208	.....	.....	.....	.....	44·35	1257	46·23	1310	90·6
9. Selipsh	1	44·08	1249	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	44·08	1249	86·4
10. Quatsimas	1	51·52	1460	.....	.....	.....	.....	2	47·14	1336	38·46	1090	42·80	1213	47·16	1336	45·70	1295	89·6
11. Songass	1	44·65	1265	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	44·65	1265	87·5
12. Bilhoolas	2	48·16	1365	47·14	1336	47·65	1350	...	.....	.....	.....	.....	.....	.....	.....	.....	47·65	1350	93·4
13. Lenni Lenape	1	47·80	1355	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	47·80	1355	93·8
14. Illinois	1	48·75	1382	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	48·75	1382	95·5
15. Comanche	1	43·42	1230	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	43·42	1230	85·1
16. Caribs	2	44·81	1270	42·18	1195	43·49	1232	2	42·18	1195	40·94	1160	41·56	1178	42·52	1205	42·32	1199	82·9
17. Muiscas	8	51·52	1460	39·70	1125	44·88	1272	4	44·66	1266	40·94	1160	42·84	1214	43·86	1243	44·92	1273	88
18. Yunca	...	.....	.....	.....	.....	.....	.....	1	44·65	1265	.....	.....	.....	.....	.....	.....	44·65	1265	87·5
19. Quichuas	3	45·02	1276	43·42	1230	44·15	1251	2	41·60	1179	38·46	1090	40·03	1134	42·00	1193	42·54	1206	83·4
20. Chauca	...	.....	.....	.....	.....	.....	.....	1	42·84	1214	.....	.....	.....	.....	.....	.....	42·84	1214	84
21. Aymaras	5	50·86	1441	44·08	1249	47·22	1338	...	.....	.....	.....	.....	.....	.....	.....	.....	47·22	1338	92·5
22. Colla	...	.....	.....	.....	.....	.....	.....	1	37·87	1073	.....	.....	.....	.....	.....	.....	37·87	1073	74·2
23. Charcas	2	44·66	1266	43·42	1230	44·08	1249	1	41·60	1179	.....	.....	.....	.....	42·84	1214	43·22	1225	84·7
24. Araucanians	5	58·96	1671	42·84	1214	49·33	1398	1	41·60	1179	.....	.....	.....	.....	45·46	1288	48·02	1361	94·1
25. Paraguay Indian	1	41·45	1175	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	41·45	1175	81·2
26. Gran Chaco Indian.....	1	51·52	1460	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	51·52	1460	101
27. Arawack	...	.....	.....	.....	.....	.....	.....	1	41·60	1179	.....	.....	.....	.....	.....	.....	41·60	1179	81·5
28. Caribi	...	.....	.....	.....	.....	.....	.....	1	37·22	1055	.....	.....	.....	.....	.....	.....	37·22	1055	72·9
29. Tarumas	...	.....	.....	.....	.....	.....	.....	2	42·84	1214	36·63	1038	39·70	1125	.....	.....	39·70	1125	77·8
30. Macusi.....	1	47·80	1355	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	47·80	1355	93·8
31. Wapisiana	1	41·30	1170	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	41·30	1170	80·9
32. Orinoco Indian	1	47·80	1355	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	47·80	1355	93·8
Numbers and Averages	52	48·16	1360	43·50	1233	46·17	1308	31	45·44	1288	39·13	1109	41·89	1187	44·92	1273	44·64	1265	87·5

TABLE V.—AUSTRALIAN RACES.

1. Australians	17	53·35	1512	36·71	1040	42·25	1197	7	44·08	1249	34·15	968	39·62	1123	40·93	1160	41·38	1173	81·1
2. Tasmanians	7	48·38	1371	37·22	1055	43·42	1230	4	41·89	1187	35·39	1003	38·82	1100	41·12	1165	42·25	1197	82·8
Numbers and Averages	24	50·86	1441	36·96	1047	42·83	1214	11	42·98	1218	34·77	985	39·22	1111	41·02	1162	41·81	1185	81·9

Table VI.—OCEANIC RACES.

1. Nicobarian	1	40·35	1143	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	40·35	1143	79·1
2. Nians	2	44·44	1259	38·23	1083	41·33	1171	1	44·66	1266	.....	.....	.....	.....	42·99	1218	43·47	1232	85·2
3. Sumatrans	7	51·52	1460	41·60	1179	45·81	1301	...	.....	.....	.....	.....	.....	.....	.....	.....	45·81	1301	89·8
4. Malays	6	54·00	1530	45·32	1313	50·13	1421	2	38·46	1090	37·58	1065	38·02	1077	44·07	1249	47·07	1334	92·3
5. Bankans	2	53·37	1513	53·35	1512	53·36	1512	...	.....	.....	.....	.....	.....	.....	.....	.....	53·36	1512	104·6
6. Javans	30	54·59	1547	40·94	1160	47·21	1338	6	45·90	1301	39 11	1108	41·45	1175	44·33	1256	44·66	1266	87·5
7. Madurans	10	56·48	1601	46·56	1319	50·79	1439	...	.....	.....	.....	.....	.....	.....	.....	.....	50·79	1439	99·5
8. Balinese	3	50·86	1441	40·94	1160	44·44	1259	...	.....	.....	.....	.....	.....	.....	.....	.....	44·44	1259	87·1
9. Bimanese	1	49·62	1406	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	49·62	1406	97·3
10. Timorese	1	47·14	1336	.....	.....	.....	.....	1	42·18	1195	.....	.....	.....	.....	44·66	1266	44·66	1266	87·5
11. Amboynese	4	53·35	1512	45·90	1301	48·38	1371	1	37·58	1065	.....	.....	.....	.....	42·98	1218	46·19	1309	90·5
12. Tidorese	2	52·76	1495	47·83	1355	50·28	1425	...	.....	.....	.....	.....	.....	.....	.....	.....	50·28	1425	98·5
13. Alfourous	2	47·14	1336	45·03	1276	46·05	1305	1	44·08	1249	.....	.....	.....	.....	45·06	1277	45·41	1287	89
14. Celebeans	8	51·52	1460	41·60	1179	45·97	1303	2	47·51	1346	45·25	1282	46·38	1314	46·17	1308	46·51	1318	91·2
15. Dayaks	12	50·28	1425	37·22	1015	44·80	1270	4	43·42	1230	40·94	1160	41·81	1185	43·30	1227	44·08	1249	86·4
16. Bisayans	5	48·38	1371	43·42	1230	44·73	1268	3	43·78	1241	42·18	1195	43·20	1224	43·96	1246	44·08	1249	86·4
17. Negritos	2	43·20	1224	37·87	1073	40·53	1149	...	.....	.....	.....	.....	.....	.....	.....	.....	40·53	1149	79·4
18. Oolean	1	42·13	1194	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	42·13	1194	82·6
19. Papuans	3	49·62	1406	45·32	1284	46·78	1326	1	43·20	1224	.....	.....	.....	.....	44·99	1275	45·76	1297	89·7
20. Salomon Islanders	3	45·20	1281	41·30	1170	44·15	1251	1	44·08	1249	.....	.....	.....	.....	44·11	1250	44·15	1251	86·5
21. New Caledonians	4	49·62	1406	45·32	1284	47·14	1336	1	40·35	1152	.....	.....	.....	.....	43·74	1240	45·97	1303	90·1
22. Loyalty Islanders	1	45·68	1295	.....	.....	.....	.....	2	50·86	1441	43·42	1230	47·14	1336	46·41	1315	46·65	1322	91·4
23. New Hebrideans	9	49·04	1390	40·94	1160	44·66	1266	1	44·08	1249	.....	.....	.....	.....	44·37	1257	43·92	1245	86·1
24. Feejeeans	...	.....	.....	.....	.....	.....	.....	2	42·84	1214	41·30	1170	42·07	1192	.....	.....	42·07	1192	82·4
25. Maoris	5	48·39	1371	42·18	1195	45·19	1281	...	.....	.....	.....	.....	.....	.....	.....	.....	45·19	1281	88·6
26. Eimeoan	1	47·14	1336	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	47·14	1336	92·4
27. Bolabolan	1	45·90	1301	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	45·90	1301	90
28. Gambier Islander	1	46·56	1319	.....	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	.....	46·56	1319	91·3
29. Marquesan Islanders	16	54·59	1547	42·18	1195	47·80	1355	11	50·64	1435	41·10	1165	43·20	1224	45·50	1289	46·56	1319	91·3
30. Kanakas	67	55·61	1576	37·87	1073	47·89	1357	54	52·76	1495	38·24	1084	43·78	1241	45·83	1299	45·97	1303	90·1
Numbers and Averages	210	49·25	1396	42·90	1216	46·54	1319	95	44·61	1264	41·01	1162	43·00	1219	44·52	1272	45·63	1293	89·4

SUMMARY OF THE SIX TABLES.

I. European Races	299	52·68	1493	43·61	1236	48·25	1367	94	46·02	1304	39·56	1121	42·49	1204	45·73	1296	47·12	1335	92·3
II. Asiatic Races	124	50·27	1425	41·57	1178	46·00	1304	86	45·95	1302	37·48	1062	42·13	1194	43·94	1245	44·44	1259	87·1
III. African Races	53	47·37	1342	41·93	1188	45·63	1293	60	43·91	1244	39·59	1122	42·74	1211	43·66	1237	43·89	1244	86
IV. American Races	52	48·16	1365	43·50	1233	46·17	1308	31	45·44	1288	39·13	1109	41·89	1187	44·92	1273	44·64	1265	87·5
V. Australian Races	24	50·86	1441	36·96	1047	42·83	1214	11	42·98	1218	34·77	985	39·22	1111	41·02	1162	41·81	1185	81·9
VI. Oceanic Races	210	49·25	1396	42·90	1216	46·54	1319	95	44·61	1264	41·01	1162	43·00	1219	44·52	1272	45·63	1293	89·4
Numbers and Averages	762	49·76	1410	41·74	1183	45·90	1301	377	44·81	1270	38·59	1094	41·91	1188	43·96	1246	44·58	1263	87·3

NOTES TO TABLE I.—European Races.

1. *Ancient Britons.*—The average weight of the brain in 56 skulls of men is 52·54 oz., or 1489 grms.; that of 10 women 43·27 oz., or 1226 grms. The mean of the sexes is 47·90 oz., or 1357 grms.; the mean of the series gives a brain-weight of 45·83 oz., or 1299 grms.

2. *Ancient Scottish.*—The mean of these 5 skulls, 3 of men and 2 of women, is 43·42 oz., or 1230 grms.

3. *Ancient Romano-Britons.*—The mean weight of brain deduced from 56 crania, 44 of which are those of males and 12 of females, is 45·97 oz., or 1303 grms.

4. *Anglo-Saxons.*—The average brain-weight of about the same number of Anglo-Saxon crania, in which the males and females are nearly in the same proportion, is very nearly the same, viz. 45·46 oz., or 1288 grms.

5. *English.*—The average brain-weight of 21 English men is 50·28 oz., or 1425 grms.; that of 13 English women 43·13 oz., or 1222 grms. That of the entire series, of which three-fifths are those of men and two-fifths those of women, is 47·50 oz., or 1346 grms. It should here be observed that the great design kept in view in forming the collection of skulls from which our data are derived was to acquire *exotic* crania. Not a single English example has been sought for, and some of those which have accidentally fallen into our hands may be poor specimens; so that the average weight of the English brain may be a little higher than is here set down. Still, a comparison with actually tested weights of brains shows that there cannot be any material error.

Dr. T. B. PEACOCK has made two series of metrological observations on the weight of the brain. The first was conducted at the Edinburgh Infirmary, and therefore refers to the brains of the *Scotch*. The second was conducted in London, and related to *English* brains. Dr. THURNAM has analyzed Dr. PEACOCK's Tables, and gives as the result that he found the Scotch adult male brain to weigh on the average 50 oz. av., and that of the English 49 oz.*

In the former series of observations by Dr. PEACOCK upon the Scotch brains, he states as his first conclusion that "The encephalon in the adult male weighs, on an average, 50 oz. 3·25 dr., or 3 lb. 2 oz. and $3\frac{34}{131}$ drachms avoirdupois, and exceeds in weight that of the female by 5 oz. 4·95 dr., the latter weighing on an average 44 oz. and 14·3 dr., or 2 lb. 12 oz. $14\frac{28}{74}$ dr."†. To express Dr. PEACOCK's conclusion in our mode, it is as nearly as may be that the male brain weighs 50·34 oz., and the female 44·15 oz. Our results give 50·28 oz. and 43·13 oz. respectively for the English brain.

Dr. PEACOCK's Note deserves to be quoted. It is to the following effect:—"A comparison of these averages, with those deduced by Dr. REID, will show that they correspond very closely, though the numbers on which the calculations are based are considerably extended. They do not differ, also, very greatly from the conclusions of Sir

* "On the Weight of the Brain, and on the Circumstances affecting it, by JOHN THURNAM," Journal of Mental Science, vol. xii. p. 15.

† *Op. cit.* p. 19.

Wilaiam Hamilton, Dr. Sims, and Dr. Clendinning. Sir W. Hamilton estimated the weight of the adult male encephalon at 3 lb. 8 oz. troy, and the female at 3 lb. 4 oz., which are nearly 48 oz. 5 dr. and 43 oz. 15 dr. avoirdupois. On calculating the weights of the brain in the two sexes separately, from the observations published by Dr. Sims, I find the male brain, in 54 persons between 20 and 60 years of age, to average 47 oz. 13 dr.; and the female brain, in 58 persons, 44 oz. and 10 dr. Dr. Clendinning states the male brain, in persons between 21 and 60 years of age, to average 45·85 oz., and the female 41·25 oz. These several averages, together with those deduced by Dr. Reid and myself, range between $45\frac{3}{4}$ oz. and $50\frac{1}{4}$ oz. for the male, and $41\frac{1}{4}$ oz. and nearly 45 oz. for the female"*.

Dr. Robert Boyd states, as the result of his great and continued metrological labours upon the weight of the brain, that the average weight of the encephalon in *insane* males at adult age, varied from 48·17 oz. to 43·87 oz., and in *insane* females from 44·55 oz. to 40·55 oz.; and that in the *sane* at the same period of life, the average varied in the male from 48·2 oz. to 45·34 oz., and in the *sane* female from 43·7 oz. to 39·77 oz. To place this in another form, it may be said that the average weight of the brain in *insane* English men was found to be 46·02 oz., or 1304 grms.; and in *insane* English women 42·55 oz., or 1206 grms. In the *sane* English brains the average for the men was 46·77 oz., or 1325 grms.; and for the women 41·73 oz., or 1183 grms., or, taking both together, the mean would have been 44·25 oz., or 1262 grms.†. It will be seen that this result does not quite agree with the weight as deduced from the capacity of our English skulls, nor with Dr. Peacock's observations with the scales. It is rather more than two ounces less than our mean, and three ounces less than Dr. Peacock's.

The conclusions given by Dr. Thurnam from the examination, by actual weighing, of the brains of 257 insane men and 213 insane women, who died in the Wiltshire County Asylum, agree very closely with those of Dr. Boyd. The average weight of the former was 46·2 oz., or 1309 grms.; that of the latter 41 oz., or 1162 grms., producing a mean of the men and women of 43·6 oz., or 1236 grms., a little less than the mean derived from Dr. Boyd's results.

6. *Irish.*—The Irish brains of these 28 skulls have been slightly larger than those of the English. Still the mean of the series is less, viz. English, 47·50 oz., or 1346 grms.; Irish, 46·70 oz., or 1323 grms.

8. *French.*—Of these there are 16 examples, 9 of men and 7 of women, or nearly an equality of the sexes. The mean of the series is 45·17 oz., or 1280 grms. They are decidedly below the English.

Dr. Parchappe weighed a few French brains, and the result, as stated by Dr. Thurnam‡,

* *Op. cit.* p. 19.

† "Tables of the Weights of the Human Body and Internal Organs in the Sane and Insane of both sexes at various ages, arranged from 2614 post-mortem examinations. By Robert Boyd, M.D.," Philosophical Transactions, 1861, p. 261.

‡ *Loc. cit.* p. 15.

was an average brain-weight of 47·9 oz., or 1358 grms., *i. e.* two ounces more than our mean.

The results derived from our 16 French skulls may be compared with those obtained by Professor Paul Broca from carefully gauging the internal capacities of a large series of French crania of both sexes*. These were 115, derived from a vault in the Cité at Paris, and considered to be of the XII.th century, which gave a mean capacity of 1425 cub. centims.; 117 derived from the Cemetery of the Innocents, having a mean capacity of 1409·031 cub. centims.; and 125 others from the Cemetery de l'Ouest, at Paris, skulls of the XIX.th century, which gave a slightly greater internal capacity, viz. 1461·53 cub. centims. By first of all subjecting these figures to our rule of the deduction of 15 per cent., and then reducing them to the weight of brain they represent, the following results are produced. The 115 French skulls of the XII.th century must have held brains averaging 44·37 oz., or 1257 grms.; those of the Innocents, 43·93 oz., or 1245 grms.; and those of the XIX.th century, 45·46 oz., or 1288 grms. This gives a mean of the whole 357 French crania, which are both those of men and women, the relative number of the two sexes not having been stated, of 44·58 oz., or 1263 grms., only 17 grms. below our reduced general average,—a result which shows a remarkable agreement between the two different series of observations. Besides which it seems to indicate that the rough allowance of 1300 grms. to the French brain, by Professor Huschke, is sufficiently liberal.

11. *Italians.*—15 skulls of Italians, 13 those of men and only 2 those of women, give averages agreeing closely with those deduced from the crania of the two sexes of English. Dr. Weisbach gauged the skulls of 27 Italian men of the Austrian dominions, and his observations, when reduced to our standard, give an average of 46·19 oz., or 1309 grms.†, again closely agreeing with our series, which afford 47·58 oz., or 1348 grms.

12. *Lapps.*—7 skulls of Lapps, of pure blood, exhibit weights of brain very nearly equal to those of our Italians, and the same as the Italian men of Dr. Weisbach‡.

13. *Swedes.*—12 skulls of Swedes, three-fourths of which are those of men, present a general mean closely agreeing with that of the English.

14, 15. *Frisians, Dutch.*—These skulls again agree in brain-weight with the English.

16. *Germans.*—Of these there are 13 males and 2 females, or a great predominance of the skulls of men, *i. e.* about six-sevenths. Hence it might be anticipated that our mean would be high. It is 50·28 oz., or 1425 grms. It is probable that our crania of the men are unusually large, and those of the 2 women seem to be unusually small. The mean of the series of German skulls exceeds our English mean.

The late Professor Huschke weighed a number of brains of Germans, and these are

* Bulletins de la Société d'Anthropologie de Paris, tome iii. p. 106 (1862).

† Beiträge zur Kentniss der Schädelformen österreichischen Völker, 1867, S. 76, I. Abtheilung.

‡ The Lapps are short people. Among 8 Lapp men the mean stature was found to be 5 ft. 0·3 in., among 3 Lapp women the mean was 4 ft. 8·7 in. Notwithstanding this low stature the brain-weight of the Lapps is seen to be considerable.

the averages he obtained*. In the encephala of 40 adult men the mean weight was 1384 grms., of 22 adult women it was 1244 grms., and the mean of the two sexes, in these unequal numbers, was 1314 grms. In comparing these results of Professor Huschke with our Table, it is seen that our German skulls of men are much above, and those of our women below the average size. The mean of our entire series exceeds that of Huschke's series by 100 grammes. The late Professor Rudolph Wagner weighed the brains of 31 Germans, 18 of men and 13 of women. The results of these metric observations are that the mean weight of the 18 brains of men was 1392 grms., and of the 13 brains of women 1209 grms., which confirms the remarks already made with respect to our male skulls, and our females also. By combining the means of both sexes, and embracing the observations of Huschke, Wagner, and those of our Table, we obtain a mean of 1314 grms. as the mean weight of the brain in Germans. In a series of investigations by Professor Hermann Welcker, he filled 30 normal adult skulls of German men and 30 of women with husked wheat corns, and then poured the grains into a graduated glass measure, so as to obtain the internal capacity of each in cubic centimetres. By the deduction of 15 per cent., and the conversion of his means into their equivalents of brain, we obtain these results. The average weight of brain of the 30 men was 45·17 oz., or 1280 grms., that of the 30 women 40·50 oz., or 1148 grms., and the mean of the two sexes 42·83 oz., or 1214 grms.† It will thus be seen that the brains of Welcker's 60 skulls, both those of the men and those of the women, are smaller than the averages obtained from the three former sources. And the same will be made apparent if we refer to the observations of Dr. Weisbach, who, however, made them upon the German people of Austria, who cannot be regarded as a pure German race. The average of his 50 men is 47·36 oz., or 1342 grms. of brain, and that of 19 women 40·94 oz., or 1160 grms., the mean of the two sexes being 44·15 oz., or 1251 grms.‡ So that there is a considerable probability that the magnitude of the brain among Germans has been overestimated§.

17. *Russniak.* 18. *Poles.*—We here enter upon the decidedly brachycephalic races of eastern and south-eastern Europe. In this series of skulls to the end of the Table, with the exception of the Wallachian Gipsies, it must be expressly noted that we have the skulls of men only, therefore we get the weights of male brains solely, the great reason why the figures are so high. In this division we shall be able to avail ourselves of the elaborate researches of Dr. A. Weisbach on the skull-forms of Austrian people. The method he employed was that of filling each skull well with groats, and thus

* Schædel, Hirn und Seele des Menschen und der Thiere, Jena, 1854, S. 113.

† Untersuchungen über Wachsthum und Bau des menschlichen Schädels, 1862, S. 35, 130.

‡ *Op. cit.* S. 34, 56.

§ Without supposing that brain-weight stands in *direct* relation to stature, authentic data concerning the latter deserve attention. Dr. A. Weisbach gives the results of his observations on the stature of the Germans. The measurement of 30 men afforded an average of 1680 millims., or 5 ft. 6·2 in.; of 11 women 1544 millims., or 5 ft. 0·9 in.—Reise der Novara. Anthropologischer Theil. Körpermessungen. Tabelle VII. 1867.

obtaining the cubic contents in centimetres. There will be this advantage, that Dr. Weisbach's observations were made upon the crania of young *men* only, soldiers dying in the Military Hospitals of Vienna, with which he was connected. His results will be subjected to the usual deduction of 15 per cent., and converted into their equivalents of ounces of brain, and the corresponding grammes. Our two Poles give a mean brain-weight of 47·14 oz., or 1336 grms. Dr. Weisbach deduces a mean internal capacity from his 25 Polish skulls of 1517·42 cub. centims. By subjecting this volume to our process we obtain a weight of brain of 47·21 oz., or 1338 grms., which is almost identical with the result of our observations, being but 2 grms. more. The result of Weisbach's gauging of his 15 Russniak skulls, when reduced, is a brain-weight of 47·07 oz., or 1334 grms., showing that ours is an unusually capacious one.

19. *Czechs.*—Two skulls of men yield exactly the same mean brain-weight as the two Poles, viz. 47·14 oz., or 1336 grms. One of our Czech crania is unusually large. Dr. Weisbach's mean of 28 Bohemian skulls does not exceed 45·32 oz., or 1284 grms.

20. *Magyar.*—One man yielding a brain-weight of 45·03 oz., or 1276 grms. Dr. Weisbach's mean of 29 men's crania is 44·30 oz. of brain, or 1255 grms.

21. *Slovak.*—This male skull affords a brain-weight of only 43·78 oz., or 1241 grms. The mean deduced from Dr. Weisbach's 9 Slovak men is also somewhat low, viz. 45·76 oz., or 1297 grms.*

22. *Finns.* 23. *Russians.* 24. *Turks.*—These three classes yield considerable brain-weights, viz. 48·31 oz., or 1369 grms., 50·28 oz., or 1425 grms., and 47·58 oz., or 1348 grms. The Russians, which are the heaviest, are most probably represented by exceptionally large skulls.

25. *Rumanyos*, or Wallachians.—These people are not a branch of the Sclavic family. The 6 male crania yield a brain-weight of 45·97 oz., or 1303 grms.

26. *Gipsies* of Wallachia.—These consist of 2 skulls of men and 2 of women. They afford an average brain-weight of the men of 43·93 oz., or 1245 grms., and of the women of 43·20 oz., or 1224 grms. Thus exhibiting an unusual uniformity in the two sexes, and also a marked diminution of brain-weight when compared to that of the Rumanyos, among whom they live.

The general average of brain-weights of the whole series of 393 skulls of European Races, in unequal numbers as to sexes, about 3 males to 1 female, is 47·12 oz., or 1335 grms., which must be regarded as a high average.

Without attaching any more importance to it than it deserves, the order of the brain-weights of this series of European crania may here be stated, beginning with the highest and descending to the lowest. Russniak, one single example, a megalocephalic skull, Merovingian Franks, Germans, Russians, Frisians, Spaniards and Portuguese, Finns, Swedes, Italians and Turks, English, Dutch, Ancient Romans of Italy, Poles and Czechs, Irish, Lapps, Ancient Romano-Britons and Rumanyos, Ancient Britons, Anglo-Saxons,

* Dr. Weisbach found the mean stature of 20 men of Slavic races to approach very closely to that of his German men, viz. 1678 millims.

French, Magyar, Slovak, Ancient Scottish, and Gipsies; the Gipsies standing the lowest in the whole series of European peoples in brain-weight, and, so far, supporting their supposed Indian origin.

Table II.—Asiatic Races.

In entering upon the Asiatic Races, we shall perceive a striking diminution in the volume of the brain at the commencement of the series.

1. *Vedahs* of Ceylon.—The three skulls of men give an average of 45·51 oz., or 1290 grms., that of five women is only 39·33 oz., or 1115 grms., the former being kept up by a megalocephalic cranium with an unusual brain-weight of 57·58 oz., or 1632 grms. The general mean of the series is nevertheless only 41·23 oz., or 1168 grms.

2. *Cingalese.*—The 6 men have an average of 47·21 oz., or 1338 grms.; the 5 women of 42·98 oz., or 1218 grms.; the mean of the entire series being 45·32 oz., or 1284 grms.

3. *Afghans.*—It is almost the same with the Afghans as with the Vedahs, the average of the 4 men is 45·32 oz., or 1235 grms., notwithstanding one of the series is a megalocephalic skull giving a brain-weight of 58·96 oz., or 1671 grms. The diversity of magnitude in crania occurring in the same race is well exemplified in two of these male specimens, as given in the Table. The mean of the entire series of males and females is only 42·11 oz., or 1193 grms.

4. *Hindoos.*—The 35 male Hindoos give an average brain-weight of 44·22 oz., or 1253 grms.; the 31 women of 39·99 oz., or 1133 grms.; and the mean of the entire series is 42·11 oz., or 1193 grms., which is exactly the same as that of the Afghans. Both general means are so low that they are almost equalled by that of the small Vedahs of Ceylon. This extraordinary difference in the weight of the brains in the races of India from those of Europe seems to be deserving of the serious consideration of the advocates of the Indo-Germanic, or Aryan hypothesis. The mean brain-weight of Hindoos is one-tenth less than that of Germans and English. Dr. Morton in his Table introduces his "Indostanic Family," which is composed of 8 "Ayras" and 25 Bengalees, mixed of the two sexes, and when his means are reduced to our standard, according to our rules, they exhibit a general mean of 41·74 oz., or 1183 grms., which is a little less, about 10 grms., than our mean. The results we have thus obtained go far to justify, if they do not entirely justify, the depreciatory estimate of Professor Huschke, when he roughly stated the brain-weight of the Hindoos at from 1000 to 1100 grms.

5. *Mussulmans.*—A comparison of the averages of the brain-weights of these skulls with those of the Hindoos, shows a slight advantage in favour of the Mussulmans.

6. *Khonds.*—The 2 skulls of *men* of this race of the unquestioned aborigines, or Hill Tribes, of India, give a very small mean, only 37·87 oz., or 1073 grms., which is a difference of brain-weight amounting to nearly 6 ounces less than the mean of English *women*.

8. *Lepchas.*—As we ascend the Himalayan slope we meet with races having an

increased weight of brain. The 13 Lepchas, which include almost an equal number of men and of women, give a mean of 44·08 oz., or 1249 grms.

9. *Bodos.* 10. *Bhotias.*—These two races agree in having an equally increased weight of the encephalon, the first of 45·97 oz., or 1303 grms., and the second of 45·90 oz., or 1301 grms.

11. *Mishmees.* 12. *Singpho.* 13. *Nagas.*—These three races of Assam, of whom we have male skulls only, agree in presenting a brain-weight in the medium of 47·80 oz., or 1355 grms.

14. *Siamese.*—The people of Siam are represented by 7 crania, 4 of men and 3 of women, and they come slightly below the races of Assam, the mean being 47·14 oz., or 1336 grms.

15. *Chinese.*—The Chinese are well represented by 33 skulls, 25 of men and 8 of women, or about three-fourths those of men. The mean of the series reaches to 47·00 oz., or 1332 grms*.

16. *Burmese.*—These 5 skulls of men prove that the races of Assam, Siam, China, and Burmah agree in the relative volume of brain, which is a mean on a par with the general mean of European races.

17. *Japanese.*—From the examples here given, which, however, are only one skull of each sex, it might be considered that the Japanese suffer a serious diminution of brain-weight from their neighbours the Chinese and others. The mean of the two is only 40·32 oz., or 1143 grms. Further observations will probably correct this conclusion.

18. *Aïnos.*—The European-looking skulls of the Aïnos of Yesso, present a brain-weight decidedly greater than the Japanese of this Collection.

It will be seen that the general average of the 210 skulls of Asiatic Races is 44·44 oz., or 1259 grms. That of the European Races was 47·12 oz., or 1335 grms., which shows a difference of 76 grms. in favour of Europeans.

Table III.—African Races.

In proceeding to the African Races we commence with

1. *Berbers*, and

2. *Guanches*, the old inhabitants of the Island of Teneriffe. These were people with somewhat small brains; the mean of the series of 21 skulls, the great majority of which are those of women, is 43·49 oz., or 1233 grms.†.

* The mean stature of 26 Chinese men was found by Dr. Weisbach to be 1630 millims., or 5 feet 4·2 inches, of 3 Chinese women 1475 millims., or 4 ft. 10 inches.

† The Guanches, unlike the Negroes of the adjoining Continent, were a race of small stature. The mummy at Cambridge measures 4 feet 10 inches, that of the man in the Museum of the Royal College of Surgeons of England is of the same height, and that of another man in the Museum of the Jardin des Plantes is half an inch taller. The skeleton of the woman in this last collection I found to measure only 4 feet 4 inches. It was a singular misconception on the part of Baron Al. von Humboldt, who said the Guanches were famed for their tall stature, being the Patagonians of the Old World.

3. *Negroes of Tribes unknown.*—These continental Negroes slightly exceed the insular Guanches in brain-weight. There are 16 skulls, three-fourths of which are those of men, and the general mean brain-weight is 44·08 oz., or 1249 grms.

The individual crania of different tribes, of which there are many, give different brain-weights, varying among the men from 46·92 oz., or 1330 grms., a Joloff and a Serryia, both Tribes of the Gambia, to 41·60 oz., or 1179 grms., a Fantee. There are but two of women, a Fantee 39·11 oz., or 1108 grms., and a Mandingoe only 34·15 oz., or 968 grms. These brain-weights deserve to be recorded, but are not sufficiently numerous to be of much value.

10. *Dahomans.*—These 12 crania, of which three-fourths are those of men, and the rest belonged to the Amazonian soldiers of the King of Dahomey, present a higher general mean at 46·34 oz., or 1313 grms.

14. *Bakeles.*—A warlike Tribe on the Equator, of whom there are seven specimens, a majority of which are those of women, present a general mean of the series equal to the Dahomans, viz. 46·41 oz., or 1315 grms.

It may be convenient in this place to express the general means of the series of all these Negro Tribes, from 3. *Negroes of Tribes unknown* to 21. *Manganja.* The mean brain-weights of the 38 men is 45·88 oz., or 1300 grms. That of the 31 women is 41·06 oz., or 1164 grms. And the mean of both sexes is 43·47 oz., or 1232 grms. This is a surprisingly small weight of brain, when we call to mind the assertions of Professor Tiedemann upon this subject.

The only Negro brain actually weighed by Professor Tiedemann appears to have been that of "Honoré," who died at Liège, in 1834, whose brain was preserved in spirits of wine and sent to Tiedemann. He used Nuremberg apothecaries weight in his experiments, which he seems to have regarded as equal to our troy weight, but this is not the case*. From the fact of the great change undergone by Honoré's brain by hardening in spirit, and the confusion of weights, it is not desirable to dwell upon this observation. The errors into which this distinguished physiologist was led by his sympathies for the Negro race, and which have been so often pointed out, render it advisable that we should refer to more reliable authorities.

Dr. Peacock has weighed the brains of 5 Negroes and given a Table, into which he has introduced two observations of Professor John Reid. The average brain-weight of the men is 44·34 oz., or 1257 grms., that of the women 43·50 oz., or 1233 grms., and the mean of the sexes 43·92 oz., or 1245 grms.†. This result of actual weighing is exactly 13 grms. more than our mean of the sexes. The brain of a Negro weighed by Professor Paul Broca was found to be 925 grms.; but this is not to be regarded as a satisfactory

* The Nuremberg apothecaries weight stands in relation to English apothecaries weight as 357854 to 373095. Balbi, "Abrégé de Géographie," 1833, Tableau Comparatif des Monnaies, et des Poids et Mesures, pp. 1355 and 1295.

† "On the Weight of the Brain of the Negro," Memoirs of the Anthropological Society of London, vol. i. pp. 65 and 520.

observation, since the brain had undergone much decomposition*. The brain of a Negro examined by Dr. EDMOND SIMON was found to weigh, *with the membranes*, 1226 grms.†.

As a general conclusion, without analyzing the results of TIEDEMANN'S gaugings of Negro skulls, it may be unhesitatingly asserted that the brain-weight of Negroes is positively below that of Europeans.

23. *Kafirs*.—The average brain-weight of Kafirs is considerable, and quite in contrast with that of the true Negroes. The average of 7 Kafir men is no less than 49·04 oz., or 1390 grms., and that of the series 48·16 oz., or 1365 grms.

TIEDEMANN'S friends examined for him four skulls of Kafir men, and one that of a woman. The result of these observations, which, for brevity's sake, shall be reduced to our standard, is for the whole 46·05 oz., or 1305 grms. Perhaps our examples may be of a somewhat unusual size.

25. *Bushmans*.—Finally, we have this singular race of people, inhabiting the self-same countries as the Kafirs and other Tribes, and so remarkably different from them all, especially in the development of the brain. These four skulls of Bushmans, one of a man and three of women, yield a mean brain-weight of only 39·70 oz., or 1125 grms., which is nearly a sixth less than the mean of Europeans, no doubt, a people of greater stature, and about in the same proportion less than their fellow aborigines the Kafirs.

In the elaborate and valuable account of the Brain of a Bushwoman, by Professor JOHN MARSHALL‡, there is a careful calculation of its weight in that specimen. The brain reached him in the cranium preserved in spirits of wine, which had also been injected into the carotid arteries. Professor MARSHALL endeavoured to determine by experiment the amount of loss of weight ensuing from this process of hardening in spirit. His conclusion was that it is "from one-third to one-fourth, *i. e.* as a mean seven-twenty-fourths of the original weight"§. Hence, he determines that in a recent state, when deprived of its membranes, the brain of this Bushwoman, who appears to have been rather aged, would have weighed 30·75 oz., or 875 grms. Our estimate of the weight of the smallest brain of the three Bushwomen is 37·22 oz., or 1055 grms. This is not in agreement with Professor MARSHALL'S calculated weight, still, it is fully supported by the statement of Messrs. FLOWER and MURIE, as we shall see, and also by Professor MARSHALL'S gauging of the capacity of this Bushwoman's skull.

Besides weighing the brain and carefully restoring its original weight by his experiments to ascertain loss from hardening in spirit, Professor MARSHALL gauged the capacity of the skull itself by filling it with water. He thus found the internal capacity of this Bushwoman's skull was equal to 60·64 cubic inches. Here we have both the cubic capacity of the cranium, and also the actual weight of the brain it contained determined metrologically, which might be regarded as a crucial test of the accuracy of the method we have been led to adopt. By our method followed in the Tables of this Memoir, of

* Bulletins de la Société d'Anthropologie de Paris, tome i. p. 54.

† Ibid. tome iv. p. 350.

‡ Philosophical Transactions, 1864.

§ *Loc. cit.*, p. 506.

allowing a tare of 15 per cent. for membranes and fluids, it is found that a skull of 60·64 cubic inches capacity would contain a brain weighing 31·01 oz. Professor MARSHALL weighed this Bushwoman's brain, and determined its weight in the recent state to have been 30·75 oz., or only ·26 oz., *i. e.* a quarter of an ounce less, which is a very close agreement, showing that in this case a deduction of 15½ per cent. might have been allowed, and that our rule is not excessive, and indeed affording an unexpected and critical proof of the *general* accuracy of the method*. That it is, upon the whole, the readiest and most reliable one for ordinary application in determining the true weight of the brain from the internal capacity of the skull, seems to be proved.

The weight of the Bushwomen's brain dissected by Messrs. FLOWER and MURIE was found to be 38 oz., or 1077 grms.†. This is in close approximation to our deduction from the three Bushwoman's skulls, which yield an average of 39·48 oz., or 1119 grms.‡.

The general mean of our African Races, as deduced from 113 skulls, 53 of men and 60 of women, a tolerable equal proportion, is 43·89 oz., or 1244 grms. This is 3·23 oz., or 91 grms. less than our European general mean.

TABLE IV.—American Races.

1, 2, 3. *Esquimaux.*—We have here included the Esquimaux of the whole Arctic Circle, from Greenland westwards. They have a considerable general mean brain-weight, viz. 46·56 oz., or 1319 grms.

4 to 15. *Iroquois* to *Comanche.*—A series of mostly individual skulls amounting in the whole to 18, 12 of men and 6 of women, which affords a general mean of 46·23 oz., or 1310 grms. With these may be compared the 164 crania of the "Barbarous Tribes" of MORTON'S "American Family." When the mean cubic contents of these latter are reduced to our terms, with the observation of our rule, they produce a brain-weight of only 42·84 oz., or 1214 grms., which differs by something more than three ounces from our mean.

14. *Caribs.*—These four skulls, two of each sex, produce a general mean of 42·32 oz., or 1199 grms.

Of South American Tribes.

15. *Muizcas.*—Twelve crania, 8 of men and 4 of women, produce a general mean of 44·92 oz., or 1273 grms. This is not far from the average brain-weight of the Tribes until we reach the

22. *Araucanians.*—These 6 skulls, 5 of which are those of men and one of the five a *megalocephalus*, produce a higher mean, viz. 48·02 oz., or 1361 grms.

The general mean of the whole 83 skulls of American Races, of which 52 are those of

* Perhaps in small brains the membranes will be proportionately heavier than in large ones.

† The Journal of Anatomy and Physiology, May 1867, vol. i. p. 286. Account of the Dissection of a Bushwoman, by W. H. FLOWER, F.R.S., and JAMES MURIE, M.D.

‡ Her stature was 4 feet 7½ inches, or 4 inches less than the Hottentot Venus.

men and 31 those of women, is 44·64 oz., or 1265 grms. This is 2·48 oz., or 70 grms., less than the general mean brain-weight among European Races. It is also so near the general mean of the Asiatic and African Races, as to lead to the conclusion that all three may be regarded in general as nearly equal in the weights of their brains.

Table V.—Australian Races.

We come next to the Australian Races, or the Tribes occupying the Great Australian Continent, and Van Diemen's Land. These are highly interesting people, impressed as they are so deeply with marked differences from the races of all the rest of the globe. These differences extend to their average brain-weights.

1. *Australians.*—These 24 crania of Australians, 17 those of men and 7 of women, afford a general mean brain-weight of 41·38 oz., or 1173 grms.*

2. *Tasmanians.*—Of these there are 11 examples, 7 those of men and 4 of women, and they yield a slightly higher brain-weight than the mean of the Australians. This might have been expected, as they are a distinct race, and also decidedly more robust in physical conformation than the gracile Australians.

The investigation of the 35 skulls of Australian Races, 24 of which are those of men and 11 those of women, gives a general mean brain-weight of 41·81 oz., or 1185 grms. In this they stand apart from the people of all the other great divisions of the globe by possessing the smallest brain. They have a brain-weight which is one-ninth less than that of Europeans.

Table VII.—Oceanic Races.

The last great section into which for convenience we have divided human beings. It includes the aboriginal inhabitants of all the Islands of the North and of the South Pacific Oceans. It embraces very diverse peoples, differing materially in physical conformation and every human character. Some of these races are distinguished by considerable development of the brain, whilst others are as remarkable for deficiency of brain-weight. A few brief remarks upon these peculiarities must suffice.

* Dr. Weisbach states the mean stature of two Australian men to have been 1617 millims., or 5 feet 3·7 inches, and that of two Australian women 1552 millims., or 5 feet 1·2 inch. The two Victorian Australians measured by Dr. Ludwig Becker were respectively 5 feet 2 inches and 5 feet 7½ inches. By adding to these the few reliable replies obtained by the Select Committee of the Legislative Council of Victoria, where the data were acquired by actual measurements, we obtain a mean stature of 15 Australia men of 5 feet 6 inches. (Report on the Aborigines, Victoria, 1858–59.) The only two women said to have been positively measured were respectively 4 feet 10½ inches and 4 feet 11 inches. These, together with Dr. Weisbach's examples, afford a mean of 4 feet 11·5 inches. The heights of three skeletons of male Australians are respectively 1514 millims., or 4 feet 11·7 inches, 1540 millims., or 5 feet 0·6 inch, and 1660 millims, or 5 feet 3·1 inches, in the mean 5 feet 1·9 inch. There is no reason to doubt that the stature of Australians in different regions of the continent varied, even that of different Tribes did not agree. These singular and interesting people afford convincing evidence that the weight of the brain is a special race-character.

1. *Nicobarian**. 4. *Malays.*—Eight skulls, six of men and four of women, afford one of the highest means among the Oceanic Races, viz. 47·07 oz., or 1334 grms. of brain-weight. This might have been anticipated for such a bold and enterprising race who have pushed their migrations, chiefly for commercial purposes, over almost the whole Ocean.

5. *Bankans.* 7. *Madurans*†. 12. *Tidorese.*—These three races are represented by skulls of men only, and hence their mean brain-weights are considerable—53·36 oz., or 1512 grms., 50·79 oz., or 1439 grms., and 50·28 oz., or 1425 grms.

6. *Javans*‡.—The Collection which has afforded the materials for this Memoir is rich in crania from the Dutch dominions in the East Indian Archipelago. It should be observed that among these the skulls of men predominate. Hence the higher means which prevail among the races of these islands.

Among the remaining Islands of the Pacific there are two markedly different brain-weights to be observed, of which examples may be noted here.

29. *Marquesan Islanders.* 30. *Kanakas.*—These peoples are represented by a tolerably fair number of each sex. The former in 16 skulls of men give a mean brain-weight of 47·80 oz., or 1355 grms., and among 11 skulls of women, a mean of 43·20 oz., or 1224 grms; the mean of the whole 16 being 46·56 oz., or 1319 grms. Of the Kanakas, or Sandwich Islanders, there are 67 crania of men, affording a mean brain-weight of 47·89 oz. or 1357 grms., and 54 of women, with a mean of 43·78 oz., or 1241 grms.; the mean of the entire series being 45·97 oz., or 1303 grms. If we suppose these to be representatives of the more highly endowed of the islanders of this vast Ocean, others might be selected to exhibit the less favoured races. Among these are—1. *Nicobarian.* 15. *Dayaks.* 17. *Negritos.* 18. *Oolean.* 20. *Salomon Islanders.* 23. *New Hebrideans.* In some of these, as the Nicobarian, the Negritos and the Oolean, male skulls alone produce a very low brain-weight, as 40·35 oz., or 1143 grms. for the first, 40·53 oz., or 1149 grms. for the next, and 42·13 oz., or 1194 grms., for the third. In others a great preponderance of the skulls of men raises the brain-weight to only a low mean; as the Dayaks, where there are three-fourths of the skulls those of males, the general mean is 44·08 oz., or 1249 grms. The Salomon Islanders offer the same proportion of the sexes, and the mean of the series is 44·15 oz., or 1251 grms. Among the New Hebrideans nine out of ten of the skulls are those of men, yet the mean brain-weight of the series only rises to 43·92 oz., or 1245 grms.

* The mean stature of 51 Nicobar Islanders, men, was found by Dr. Weisbach to be 1668 millims., *i. e.* 5 feet 5·7 inches. The brain-weight of the individual in the Table was only 40·35 oz.

† Dr. Weisbach found the stature of 4 Maduran men to be 1625 millims., or 5 feet 4·1 inches. This is an evidence that, although, as a general rule, the brain is found to be small in people of short races, yet it is not by any means uniformly so. In truth, this and other similar facts show that the size of the brain, like most other human peculiarities, is a race-character.

‡ Dr. A. Weisbach found the average stature of 9 Javan men to be 1679 millims., or 5 feet 6 inches, that of 8 Javan women 1461 millims., or 4 feet 9·6 inches.

25. *Maoris**.

In conclusion, a hope may be expressed that this investigation has shown that some confidence may be placed in the method which has been followed; and that there is reason to think this communication may prove a valid contribution to the important and interesting subject of the weight of the brain in the different Races of Man.

Postscript.

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The value of this communication, so far as it turns upon the proposed tare employed in its calculations, has received an important illustration, which must be alluded to here. The great politeness of an eminent Austrian anatomist, Dr. A. Weisbach, of Vienna, has afforded the means of testing this validity in a more complete manner than could be expected to occur in this country. He has taken the encephala out of 115 skulls of males and females, and carefully weighed them; subsequently, when the cranium was prepared, he has gauged its capacity in each case. The data he has thus obtained, he has had the goodness to communicate. They afford the chief materials for the following Table. The capacity is given in cubic centimetres first, then the estimated weight of the brain as deduced from our method, next the actual weight of the brain, without membranes, fluids and *medulla oblongata*, as determined by Dr. Weisbach. In order to compensate for this deficiency of the medulla oblongata, an addition of 14 grms., or half an ounce av., is made to each mean, so as to show in the next column the real weight of the entire brain. By this addition it is believed that we shall compensate as nearly as may be necessary for the absence of the medulla oblongata, which constitutes a portion of the contents of the skull. Professors Quain and Sharpey, quoting from Dr. Reid, state that the pons Varolii and medulla oblongata conjointly weigh in men $15\frac{3}{4}$ drs. av., in women 1 oz. and a quarter of a dr.†. By Dr. Robert Boyd it is said, "the average weight of the pons Varolii and medulla varied in the males from 1·15 oz. to 1·02 oz., and from 1·05 to ·95 oz. in the females"‡. Considering these observations to prove that these two portions of the contents of the cranium, the pons Varolii, and the medulla oblongata, weigh on the average about an ounce, we may conveniently regard them as each weighing half an ounce. The last column of the Table shows the exact average amount of the deficiency, or of the excess, of our estimated weight of the brain, in relation to that obtained by Dr. Weisbach's experiments.

* The mean stature of 3 New Zealand men was found by Dr. Weisbach to be 1757 millims., or 5 feet 9·2 inches.

† Elements of Anatomy, 5th ed., 1848, vol. ii. p. 672.

‡ Philosophical Transactions, 1861, p. 262.

Number of cases.	Sexes.	Ages.	Capacity of skulls.	Estimated weights of brains.	Actual weights of brains, without membranes, fluids, and medulla oblongata.	With the addition of 14 grms. for the medulla oblongata.	Differences between estimated weights and actual weights. The former more than the latter +, less than the latter −.
			cub. cent.	grms.	grms.	grms.	grms.
5	♂	10 to 19 years	1436·62	1270·06	1209·85	1223·85	46·21 +
75	♂	20 to 29 years	1535·52	1355·11	1327·43	1341·43	13·68 +
9	♂	30 to 59 years	1556·96	1374·95	1316·12	1330·12	44·83 +
11	♂	60 to 90 years	1550·43	1349·44	1227·21	1241·21	108·23 +
100	♂	10 to 90 years	1533·11	1352·27	1310·06	1324·06	28·21 +
15	♀	.....	1318·30	1165·16	1159·65	1173·65	8·49 −
115	♂ and ♀	.....	1505·09	1329·59	1290·44	1304·44	25·15 +

The results of these tests of our rule of a tare of 15 per cent., for so the experiments of Dr. Weisbach may be regarded, are that in each of the groups into which the ages are divided our estimated weight exceeds the true weight of the brain, except in the case of the brains of the 15 women. In these the estimated weight falls short of the actual weight by an average of 8·49 grms., or nearly ·30 of an ounce. The other groups stand thus, ascending from the lowest to the highest. In 75 men from 20 to 29 years of age, that is, in the vigour of life (and it is to this period of life that the great majority of the skulls of the preceding race-Tables belong), the estimate exceeds the true weight by only 13·68 grms., or about half an ounce. In the whole number of cases taken together, the excess of the estimate is 25·15 grms., or about ·90 of an ounce. In the entire group of males this excess is 28·21 grms., or as near as may be one ounce. In the 9 males from 30 to 59 years of age, when it seems that the brain begins to have an increment in its fluids, it rises to 44·83 grms., or a trifle more than an ounce and a half. Before this organ reaches its maturity, as in the group of males from 10 to 19 years of age, the excess of our estimate is almost the same, viz. 46·21 grms., or somewhat above an ounce and a half, which shows the large amount of serosity in the brain at this early period of life, when the organ is in a state of active growth. But it is in advanced life, when this serosity again abounds, that our estimate is most remote from the actual weight of the cerebral mass itself. Here the discrepancy amounts to 108·23 grms., or approaching to 4 ounces.

It must be recollected that, although our general rule is of great value in estimating the true weight of the brain from the capacity of the skull, where we have a large number of specimens of different sexes and ages before us, and is perhaps as near as any general rule that can be laid down, it is not to be expected that any uniform rate of deduction can be devised which will be correct even in the majority of individual instances, where the causes of deviation are so varied and complex. The complete test to which our rule has been put by these 115 careful experiments on brains of very different ages, shows its value and general correctness in a more satisfactory manner than could have been anticipated. If further investigations should prove that Dr. Weisbach's observations may be taken to possess an average value, it will probably be desirable to increase our rate of tare to a slight extent.